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THE JOURNAL OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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ANNUAL MEETING, NEW YORK CITY, DECEMBER 5-8

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Entered as second-class matter, January 4, 1912, at the Postoffice, New York, N. Y., under the Act of Congress of March 3, 1879

A Representative Issue

Below is a Topical Index of the subjects included in this number of The Journal. It contains ninety-four entries, covering a diversity of important subjects in many fields of mechanical engineering.

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Contributions to the Society's Proceedings from thirty-five mechanical engineers, members of the Society and others, are included in the technical section, and in addition thirty-five important papers, accounts of researches, etc., contributed to other current periodicals, are abstracted in the engineering survey section.

THE NATIONAL ENGI

The Journal of the American Society of Mechanical Engineers is th
American mechanical engineering progress presented at the m
papers are secured by local committees of expert engineers ar

DURING the season just closed, upwards of one hundred meetings have been held by the Sections of the Society all over the country. This represents a high average for each Section and is indicative of the activity of the Society in national engineering affairs. Among the papers contributed to The Journal from these meetings are the following strikingly important titles:

The Diesel Engine and Its Applications in Southern California, Walter H. Adams (San Francisco Section), November 1915.

Motion Study for the Crippled Soldier, Frank B. Gilbreth (New York Section), December 1915.

Gas Volume and Dust Concentration Determination in Connection with the Cottrell Process, Wm. N. Drew (Los Angeles Section), December 1915.

An Investigation of the Gas Producer Power Plants in New York City and Vicinity, C. N Ripley (New York Section), December 1915.

Industrial Safety and Principles of Management, W. P. Barba (Philadelphia Section), December 1915.

Standardization of Power Plant Operating Costs, Walter N. Polakov (New York Section), April 1916.

Special Steels, Samuel L. Hoyt (Minnesota Section), April 1916.

The Design and Test of a Large Reclamation Pumping Plant, G. C. Noble (San Francisco Section), May 1916.

Steam Safety Valves, George H. Clark (Boston Section), May 1916.

Report upon Efficiency Tests of a 30,000 kw. Cross-Compound Steam Turbine, H. G. Stott and W. S. Finlay, Jr. (New York Section), June 1916.

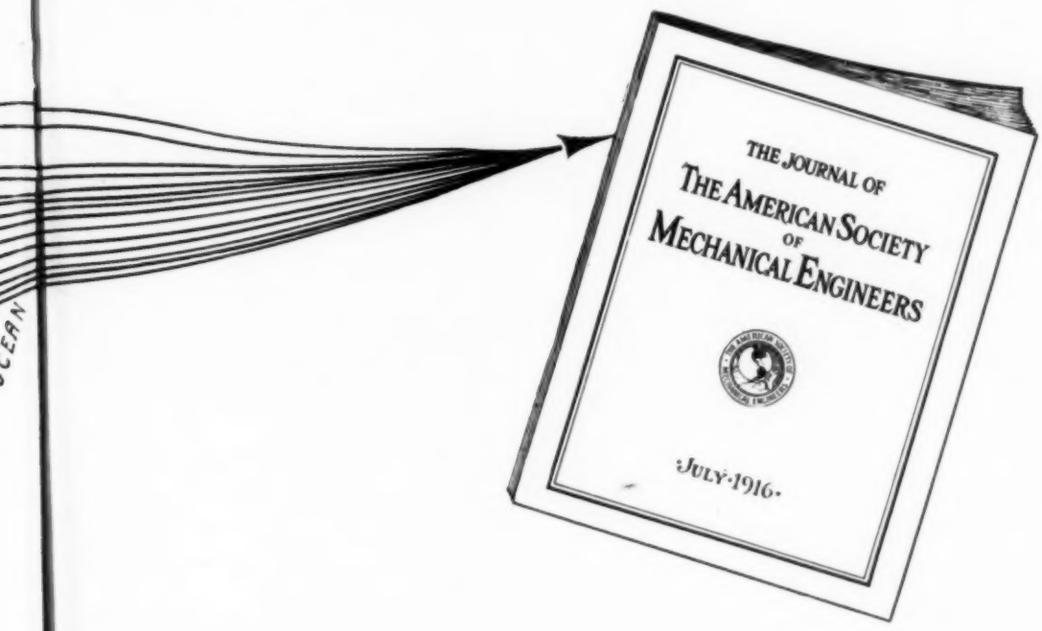
A Novel Method of Handling Boilers to Prevent Corrosion and Scale, Allen H. Babcock (San Francisco Section), July 1916.

Measurement of Steam Flow, G. E. Bailey (Boston Section). *In preparation.*

Motor Trucks in Southern California, W. Howard Clapp (Los Angeles Section). *In preparation.*

The Use of Powdered Coal as a Fuel, Joseph Harrington (Chicago Section). *In preparation.*

Pulverized Fuel Installation under 10-250 h. p. Heine Boilers for M. K. & T. Ry. Co., Parsons, Kansas, H. G. Barnhurst (Chicago Section). *In preparation.*



GINEERING MONTHLY

s is the medium for the publication of the important contributions upon the monthly meetings of the Society's sixteen Sections. These eers and are the embodiment of the best thought of the day

High Temperature Insulation, P. A. Boeck (Chicago Section). *In preparation.*
Oil Engines, S. B. Daugherty (Chicago Section). *In preparation.*
Ways of Presenting Data for Executive Purposes, T. Russell Robinson (New York Section). *In preparation.*
Probable Future Requirements in Machine Tools, A. M. Sosa (Cincinnati Section). *In preparation.*
Recent Developments in the Recovery of Casing Head Gasoline, Paul Diserens (Cincinnati Section). *In preparation.*
The Sales Engineer and His Relation to Production and Machine Design, A. J. Baker (Cincinnati Section). *In preparation.*
Efficiency of Propulsive Machinery and Late Developments in Naval Engineering, Lieut. Com. H. C. Dinger (Philadelphia Section). *In preparation.*

The variety of topics covered by the papers from Sections this year is well illustrated by the following classification of subject matter:

Acetylene Welding
Automobile Engines
Boiler Water Treatment
Diesel Engines
Casing Head Gasoline
Explosives in Engineering
Gas Power Plants
High Temperature Insulation
Industrial Safety
Leather Belting
Machine Tools
Motion Study
Operating Costs
Portland Cement
Powdered Fuel
Propulsive Machinery
Reclamation Pumping
Sales Engineering
Special Steels
Specifications and Contracts
Steam Safety Valves
Steam Flow Meters
Turbine Tests

The importance of these Section papers as factors in the development of The Journal as The National Engineering monthly is obvious. Through The Journal the Society now *distributes to* all parts of the country a large quantity of original mechanical engineering data *received from* all parts of the country, through its sixteen established Sections.

THE ANNUAL MEETING

NEW YORK, DECEMBER 5 TO 8

All papers for the Annual Meeting should reach the Secretary not later than September 20. The Committee on Meetings cannot agree to consider papers received after this date.

The feature of the next Annual Meeting will be an all-day session to occur on Thursday, December 7, on the subject of the Valuation of Industrial Property. Suggestions are desired from members as to papers and names of authors, or of engineers who should be invited to discuss the papers which are presented. Among the topics which it is proposed to consider are the following:

Accurate Appraisals by Short Methods.

Does Valuation of Industrial Property Differ from Public Utility Valuation?

The Relation between Perpetual Inventory Value and Appraisal Value.

Engineering Economics of Partial Construction. To deal with "piecemeal construction" and how such construction is to be regarded in appraisals.

Amortization and Depreciation, dealing particularly with the former. The intangible elements in valuation to be discussed as well as the policy of involving the second and third generation in amortization, rather than have the present generation carry the whole burden.

Besides the usual groups of miscellaneous papers representative of the most recent investigations in mechanical engineering throughout the country, there will be sessions in charge of the Sub-Committees on Railroads, Machine Shop Practice and Gas Power, and also contributions of one or more papers each from various other committees.

THE SPRING MEETING, 1917

The 1917 Spring Meeting will be held in Cincinnati, Ohio. The entertainment will be in the hands of the Cincinnati Section, who are planning an enthusiastic reception of the Society in the Queen City.

MECHANICAL EQUIPMENT USED IN THE PORT OF NEW ORLEANS

By WILLIAM VON PHUL, NEW ORLEANS, LA.
Member of the Society

THE Port of New Orleans, about 100 miles from the Gulf of Mexico, extends for nearly fifteen miles along the Mississippi River, from Westwego and Southport above the city on the northwest, to Chalmette five miles below Canal Street. The principal commercial development is on the east bank of the river, but on the west bank, opposite the city, there are wharves and landings at Westwego, Harvey's Canal, Gretna, Algiers and McLellanville.

By the peculiar laws in force, there can be no private ownership of river front property to the exclusion of the public. The State of Louisiana owns outright the larger part of the commercial front and has the right to use all of it, appropriating any land needed and expropriating any improvements on such property if placed under grants of the proper authorities.

Until 1901 the facilities of the Port of New Orleans were

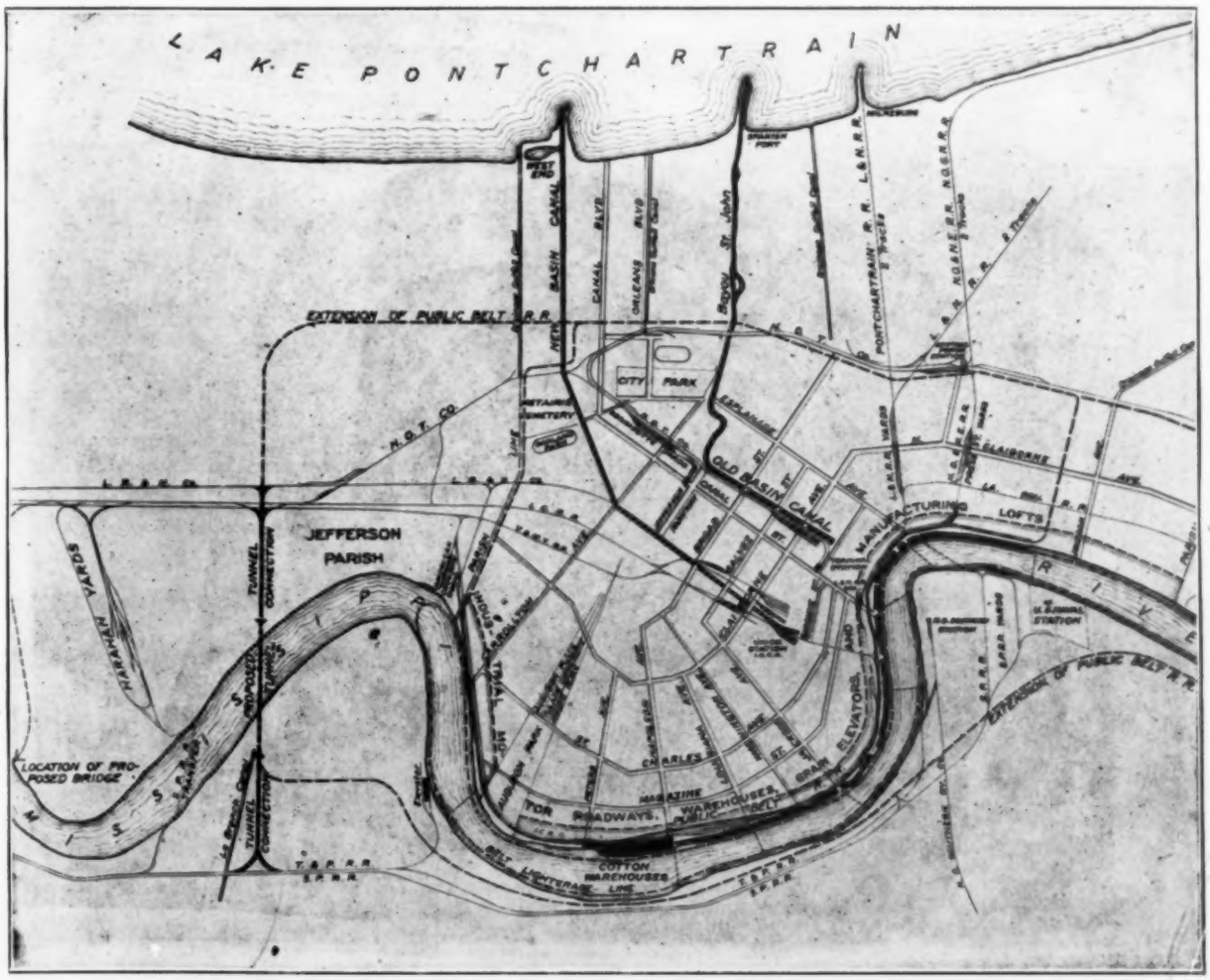


FIG. 1 PORT OF NEW ORLEANS, SHOWING COÖRDINATION OF RAIL AND WATER TRANSPORTATION

In volume of business, combining imports and exports, New Orleans is the second port of the United States, being exceeded only by New York. New Orleans is described as a two-way port, the import and export tonnage being practically equal, a condition obviously very favorable to the transportation interests. The value of the combined imports and exports averages about $1,000,000 per day.

Presented at the Spring Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New Orleans, La., April, 1916. Pamphlet copies without discussion may be obtained; price 15 cents to members, 30 cents to non-members.

provided by private interests through lease of the river frontage. The wharves were temporary structures; there were no sheds; there was no machinery, and charges assessed against vessels were considered excessive.

The Board of Commissioners of the Port of New Orleans was created by the Legislature in 1896 and in 1901 secured control of the river front.

The first Board which took charge of the facilities in 1901 was somewhat handicapped through having no other available funds than revenues produced by charges upon shipping.

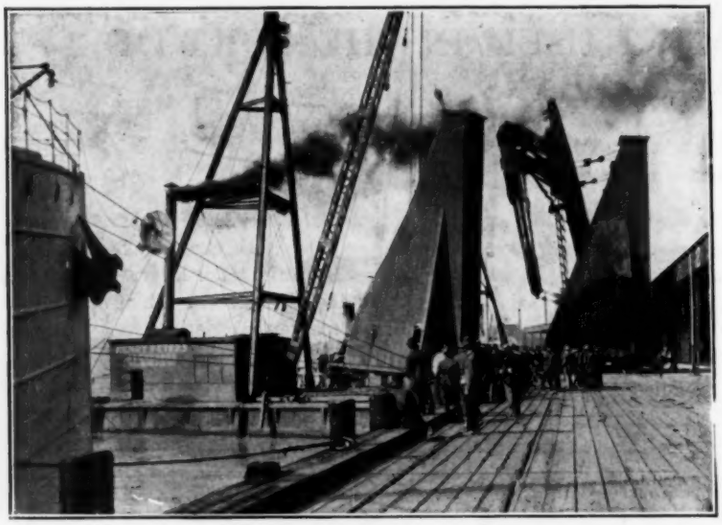


FIG. 2 BANANA UNLOADERS, PAULINE STREET WHARF

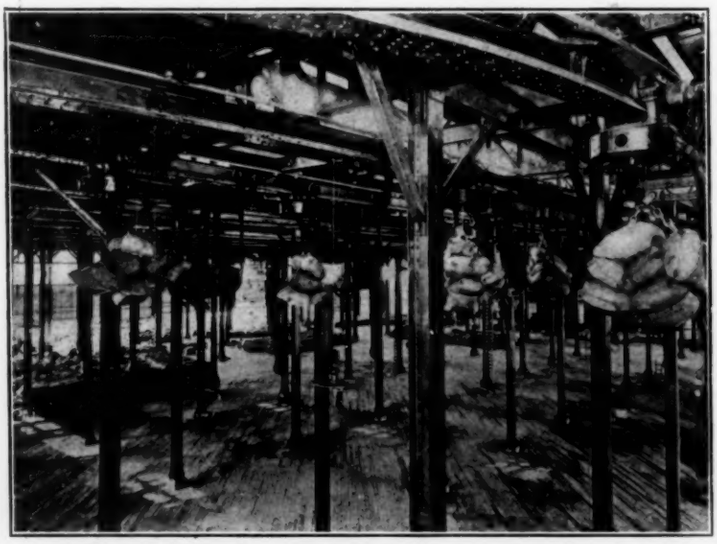


FIG. 3 TELPHERS IN CHALMETTE SUGAR REFINERY

FIG. 4 PORTABLE UNLOADER AND CONVEYOR

After a few years, however, the Legislature authorized the Board to issue bonds, and, with the proceeds of these bonds, wharves and sheds were constructed. In 1914 other bonds were issued for the construction of a Public Cotton Warehouse, and in 1915 for a Public Grain Elevator; and financial arrangements were made which will permit the prompt execution of further improvements, as adopted.

On account of this lack of funds in the early years, the facilities first constructed consisted solely of wharves for landings. The construction a few years later included closed sheds, and the more recent projects include, in addition, switch tracks generally on the wharf front, paved roadways along the rear of the wharves connecting with the city streets and mechanical devices suited to the purpose of the wharf. It is planned to rebuild promptly a large part of the existing wharf system, including in the rebuilding the additional facilities mentioned.

The river front of New Orleans is now administered by two State Boards: (1) The Board of Commissioners of the Orleans Levee District, which is empowered to acquire land and to build protective levees; (2) The Board of Commissioners of the Port of New Orleans, which has jurisdiction over the port and prescribes rules for operating vessels and controls the commercial use of the port facilities.

The wharves are served by the Public Belt Railroad, owned by the City of New Orleans and operated through the Public Belt Railroad Commission. The Belt Railroad connects with all railroads reaching the city and switches cars to and from the wharves and industries at a flat rate of two dollars per car. The Belt Railroad Commission was created in 1904 and began work in 1905, since which time construction has been carried on continuously.

The river is from one-half to three-quarters of a mile in width, and the depth within ten feet of the wharves ranges from 70 to 30 ft. Unloading can be done in midstream, but most of the vessels land broadside along the wharves, which extend out from 50 to 100 ft. from the bank. Easy access to this whole wharfage front is afforded by city streets and by railroad tracks in the rear of and upon the wharves. The levees for flood protection are very wide in the commercial district, and slope back so gradually as to be hardly noticeable. They serve the purpose of marginal streets along the water front, the wharves being built at the elevation of the levees and out beyond them.

While the developed river front is about 15 miles long there are 41.4 miles of river frontage under the control of the Port Commission. The developed harbor has a water area in excess of eleven square miles. A plan of the harbor, showing the coördination of rail and water transportation, is shown in Fig. 1.

The satisfactory design and construction of wharves and buildings on the banks of the river are made more difficult by the wide range of the water level, amounting to about 21 ft., and by the current and large amount of silt borne by the water.

The wide range of level, in particular, complicates

the design of machines for transferring cargo between wharves and vessels, involving special arrangements for adjusting the ends of conveyors and for adjusting overhead booms without fouling the rigging and wireless equipment of ships.

MECHANICAL EQUIPMENT

The mechanical equipment which has been developed in New Orleans is widely scattered through the harbor and includes several installations of special interest relating to the important industries of the port.

BANANA UNLOADERS

Banana importations at New Orleans exceed those at any other port, amounting for the year ended June 30, 1914, to 16,583,000 bunches, or equivalent to an average of 320,000 bunches per week.

The handling of this business by mechanical devices has been developed until practically all of the bananas are now unloaded by machines.

The design of this machine is complicated by the necessity for providing for a wide range of water level and for ships of various dimensions. The machine consists of a steel A-frame structure traveling lengthwise of the wharf on two rails about 21 ft. centers and carrying a structural steel main boom about 50 ft. in length, stepped about 20 ft. above the dock level.

On this boom, at a distance of about 30 ft. from the heel, is stepped an auxiliary boom twenty or more feet in length, from the end of which is swung the vertical leg of the conveyor. These two booms afford almost any desired combination of vertical and horizontal adjustment, while at the same time the main boom is sufficiently short to clear the stays and wireless rigging of the ships.

These booms and the framework carry the conveyor proper, consisting of two endless chains spaced about 5 ft. apart and running over pairs of sprockets at the foot and head of the conveyor frame, at the pivot points of auxiliary and main booms and at additional points at the discharge end of the unloader.

The distance between chains is maintained by pipe spreaders and through bolts spaced about 3 ft. centers, attached to which is a 4 ft. canvas belt, with sufficient slack between each pair of spreaders to hold a bunch of bananas when the chain is moving vertically.

Upon reaching the point of discharge the bunch is forced out of the pocket by a roller behind the belt and drops upon a short horizontal conveyor, from which the bunches are picked up by hand, inspected, sorted and loaded in cars, or disposed of locally.

The entire machine is driven through gearing and clutches by one 15-h.p. motor. The capacity of each machine is upward of 2,600 bunches per hour.

Three groups of these unloaders, consisting of 10 units, are owned by the Dock Board, the total investment being about $90,000. The most recent installa-

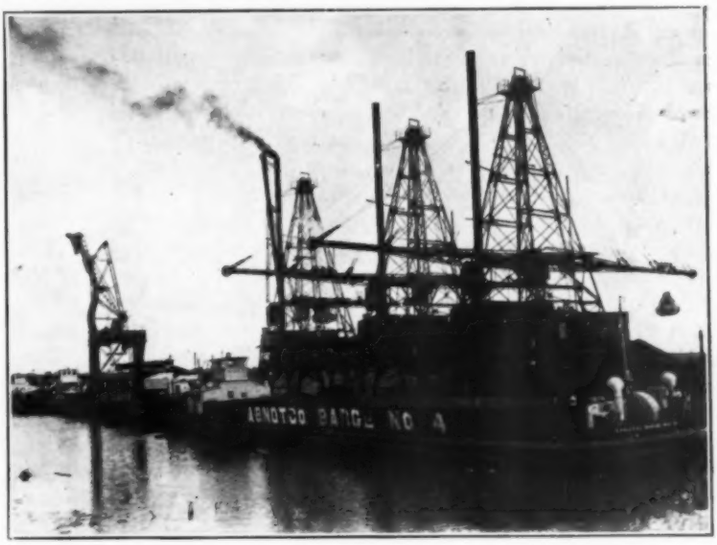


FIG. 5 TYPICAL COAL STORAGE PLANT

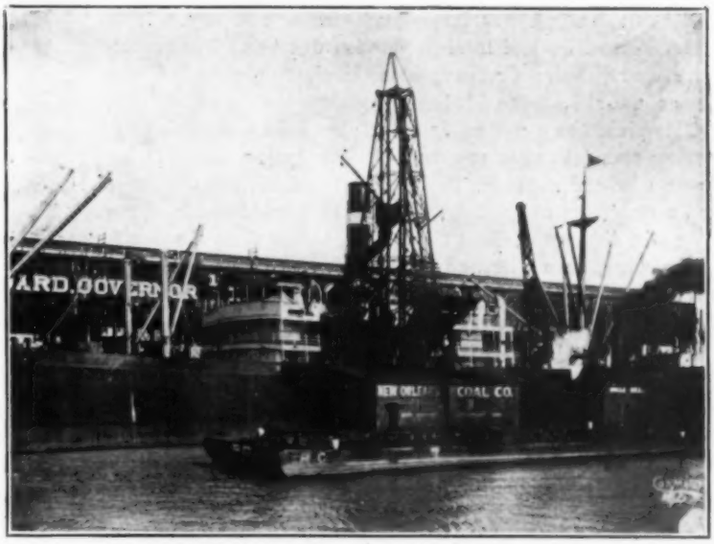


FIG. 6 TYPICAL FLOATING COAL ELEVATOR

FIG. 7 CAR FERRY INCLINE

tion is at the Pauline Street wharf, and consists of four machines costing approximately $37,500. This installation is shown in Fig. 2. The section of the wharf on which the machines operate is of pile and timber construction, with steel shed, about 360 ft. by 260 ft. As the area is covered, rain does not interrupt the discharging of cargo. The wharf is served by eight transverse spur tracks accommodating five cars each; and as one ship may carry 40,000 to 45,000 bunches or about 120 carloads, the entire track capacity may be filled and moved three times in less than a day's time. The cost to the Dock Board of this wharf with its shed and tracks was about $1.40 per square foot. In the rear of the wharf the Public Belt Railroad has yard capacity for 200 additional cars.

The Board of Commissioners makes a charge for the use of the banana conveyors of ¼ cent per bunch, which considerably exceeds the cost of operation, maintenance and interest charges.

TELPHER SYSTEM CHALMETTE SUGAR REFINERY

New Orleans receives large quantities of raw sugar from Cuba, Porto Rico and local production districts. The American Sugar Refining Company alone receives over 300,000 tons per annum at its large Chalmette refinery, just below the city.

This plant has a well equipped telpher system for receiving, storing and delivering raw sugar. This system operates between a wharf about 80 ft. by 800 ft. paralleling the river, and a storeroom about 250 ft. by 260 ft. located inside of the levee at a distance of about 200 ft. in the clear from the wharf.

The wharf is a pile and timber structure below the floor level and of heavy steel construction above, the shed covering the inshore 60 ft., while the outer 20 ft. is open.

The storeroom is of heavy steel construction, with columns set on piles and double hardwood floor laid on packed sand bed. The column spacing on the wharf is approximately 20 ft. both ways, while in the storeroom the spacing is about 20 ft. by 25 ft. Both structures are enclosed with galvanized iron, and the two are connected by four elevated runways, for the telpher system, which are also entirely enclosed. The arrangement of the telphers in the storeroom is shown in Fig. 3.

The track system for the telphers is divided into two sections, each consisting of a loop on the wharf and four loops in the storeroom. The telphers can be operated selectively over any of the loops of a section by means of a transfer or switch which connects the tracks, as desired. The two track sections can be inter-connected by a special transfer or switch on the wharf. The long wharf loop is equipped with a transfer or switch cutting off a large part of the run when ships are unloading at suitable points.

The telpher equipment consists of 25 machines; each has a capacity of seven bags of sugar weighing about 330 lb. each, or about one long ton, and is equipped with two travel motors of 6 h.p. each, on a swivel truck, and one hoist motor of 5 h.p. The telphers travel 700 ft. per min., which enables the telpher to pick up its load, make a round trip to the storeroom, discharge therein and be on the wharf ready for another trip within five minutes.

The storeroom has a maximum capacity for storing sugar of about 370,000 bags or 52,500 tons, each panel between four columns containing approximately 2500 bags when tiered 28 bags high.

Sugar arriving by boat is practically all in bags. The bags are unloaded from barges or boats by three small electric derricks on the outer face of the wharf, and from ships by the ships' tackle, in both cases being deposited on the uncovered portion of the wharf. The bags are then placed on trucks in lots of two or three and trucked to a portion of the wharf which is in reach of the telphers, in the case of imported sugar, passing over the Government scales on the way. On this floor the bags are sampled and weighed for settlement with the seller, again made up in slings, and transported by the telpher to the storeroom and there tiered as already described.

When sugar is to be used, the same telphers remove the bags from the tiers and deposit them at the shore end of the storeroom, where they are sampled and weighed for controlling the manufacturing process. At this point the sugar is removed from the bags and is carried by bucket elevators to the refinery.

The estimated capacity of this telpherage system, as outlined, is 3000 tons per working day of ten hours.

An auxiliary storage system consists of two smaller sheds located at the lower side of the main storage shed and served by an electric industrial railway which crosses under the telpher runs, where the loads are received by the cars. The tiering in these sheds is done by portable stackers.

Eight spur tracks provide facilities for bringing in or reshipping sugar by rail.

CONVEYORS FOR UNLOADING STEAMBOATS

The very low freeboard of the river steamboats and the comparatively great height of the wharves have made it difficult to move cargo from the boats to the wharves by hand. Machines have been developed for this work and a number of such machines have been used.

At present machines are in use on the steamboat wharf located just below Canal Street, the commercial center of the City. This wharf is about 1400 ft. long and has the usual shed. The machines are placed at intervals of about 200 ft.

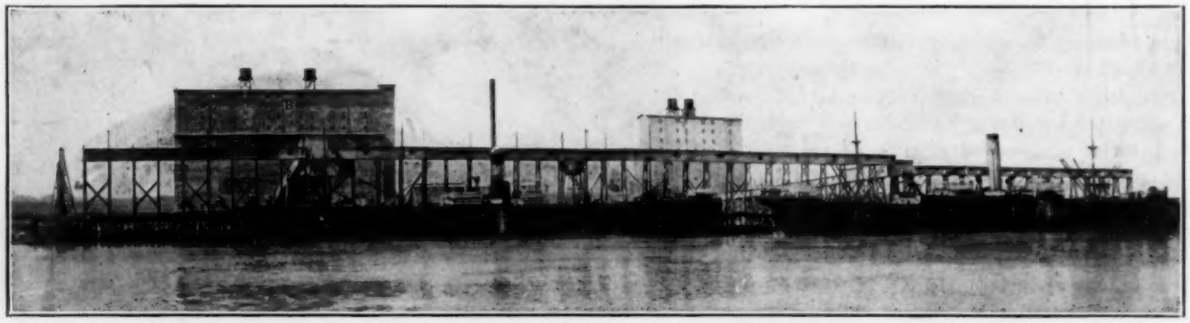


FIG. 8 TEXAS & PACIFIC RAILROAD CO.'S ELEVATORS A AND B

and consist of escalators about 50 ft. long by 3½ ft. wide, made up of a trussed timber frame fitted with a slat conveyor on which dogs for engaging the truck axles are spaced at about 5-ft. centers. The outer end of the conveyor is suspended by slings and counterbalance from a pile and timber head-frame. The conveyors were originally operated by small steam engines bolted to the framing, with boilers alongside, but these engines have now been replaced by 10 h.p. electric motors.

CONVEYORS FOR UNLOADING COASTWISE STEAMSHIPS

For loading and unloading cargo from the side ports of their steamers, the Southern Pacific Company or Morgan Line use hinged conveyor gangways. The most recent installation is at the St. Louis Street wharf and consists of three sets of gangways, each set consisting of one single and two double units about 15 ft. in width by 75 ft. in length. The double units permit of simultaneous handling from side ports and deck.

Each unit consists of a decked truss span supported by three steel trusses about 6 ft. deep, properly cross-braced. A width of about 5 ft. at one side of each unit is occupied by a slat conveyor set in flush with the decking and operated through gearing by a 15 h.p. motor, located under the gangway at the inner end.

At the outer end is a substantial structural steel frame resting on the edge of the wharf, and supporting the sheaves for counterbalance weights and hoisting gear. The gangway is raised and lowered by wire rope operating through double blocks and winding on a drum which is driven through spur and worm gearing by a motor.

In one set of these gangways 3-h.p. motors are used for hoisting, but the motion was found to be too slow and in the second and third sets installed later, and of heavier construction, 10-h.p. motors are used.

The wharf area served by these machines is about 204,000 sq. ft., with steel sheds over the full length of 1887 ft., assigned to this Company. In the year ended June 30, 1914, about 625,000 tons of miscellaneous freight crossed this wharf, or the equivalent of an average of 330 short tons per lineal foot per year.

PORTABLE UNLOADERS AND CONVEYORS

As a substitute for the conveyors just described for use on wharves not equipped with machines, there are several installations of portable sectional conveyors. These conveyors are also used to move cargo from the edge of the wharf to storage in the sheds and for stacking. One such unloader and conveyor, which has a maximum capacity of 1 ton per minute, is shown in Fig. 4.

The conveyor is made up of a number of sections, supported and connected by platforms, some of which carry the power units. The power is distributed over two, and in the case of the heavier machine, over three electric motors, instead of driving the entire equipment by one motor. With the assistance of a battery crane truck, one or two men can connect or disconnect all the sections and place them on the ground ready for moving in a few minutes, and when disconnected the whole equipment can then be drawn from place to place by motor trucks.

These conveyors have been in successful use, handling a variety of materials, particularly coffee, rice, sugar, cement, etc., in bags, coils of wire, boxes, miscellaneous packages and one of the larger machines has handled cotton bales.

COAL HANDLING EQUIPMENT

The coal companies, the transportation interests and some large consumers have established coal handling plants of some interest.

The Alabama & New Orleans Transportation Co. has a coal storage plant at Violet, just below the city on the Lake Borgne Canal near its junction with the river. The plant consists of three towers movable along tracks parallel to the canal. These towers span railroad tracks and with an extension boom reach barges in the canal and storage piles on shore.

In connection with this storage plant, the company operates barges for delivering coal in the harbor and a self-propelled steel bunkering barge of the hopper type, driven by a kerosene oil engine. The handling mechanism consists of a conveyor in the hull of the barge taking coal from the main hoppers and discharging it into the boot of a bucket elevator which in turn delivers the coal to a conveyor boom discharging on the vessel alongside.

The New Orleans Coal Company, which carries on a general bunkering business, has a shore plant for loading its barges which consists of tracks which cross a platform scale and a hopper. Below the mouth of the hopper is an electrically driven belt conveyor discharging into a barge; this barge, together with the bunkering elevator is taken by a tug to the ship which is to be coaled.

The elevator is mounted on a barge and consists of a skip raised in guides by a drum hoist, the skip receiving coal from a hopper fed by a revolving derrick equipped with a clam shell bucket. The skip hoists the coal and discharges into hinged spouts leading to the coaling hatches of the ships.

The Monongahela River Coal & Coke Company operates

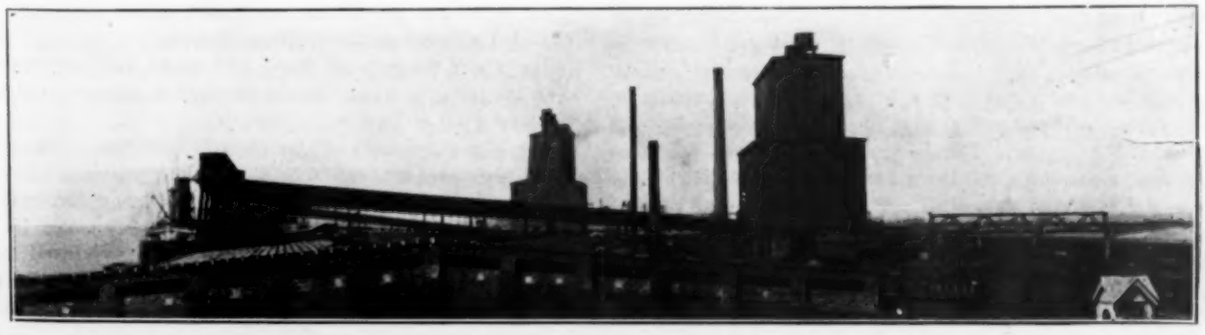


FIG. 9 ILLINOIS CENTRAL RAILROAD CO.'S ELEVATORS D AND E

floating coaling plants similar in general design to the elevator described above.

The Illinois Central Railroad has installed at Harahan, immediately above the city, a plant of 300 tons hourly capacity for transferring coal from cars to barges. Cars loaded with coal are placed in a double track gravity yard of about twenty cars capacity. The cars pass over and discharge the coal into a concrete hopper under the tracks. The hopper and tracks are covered by a frame shed. From the hopper the coal is carried by a 36-in. belt conveyor through a gallery for about 150 ft. to a 50-ft. adjustable boom which is suspended from a gallows frame and extends over the barges. The plant is

barges or colliers and store it, delivering it again as desired into ships' bunkers.

This plant consists of a steel and concrete storage house with elevated bins and steel wharf structure which is also provided with bins and surmounted by a moving tower carrying a clam shell bucket. The two structures are connected across the levee by a covered conveyor gallery.

In storing, coal is transferred from the vessel by a 2-ton clam shell bucket to the center hopper on wharf. The coal is then spouted to the main conveyor which carries it along the conveyor monitor of the storage house and, by means of adjustable trips, distributes it in the bins.

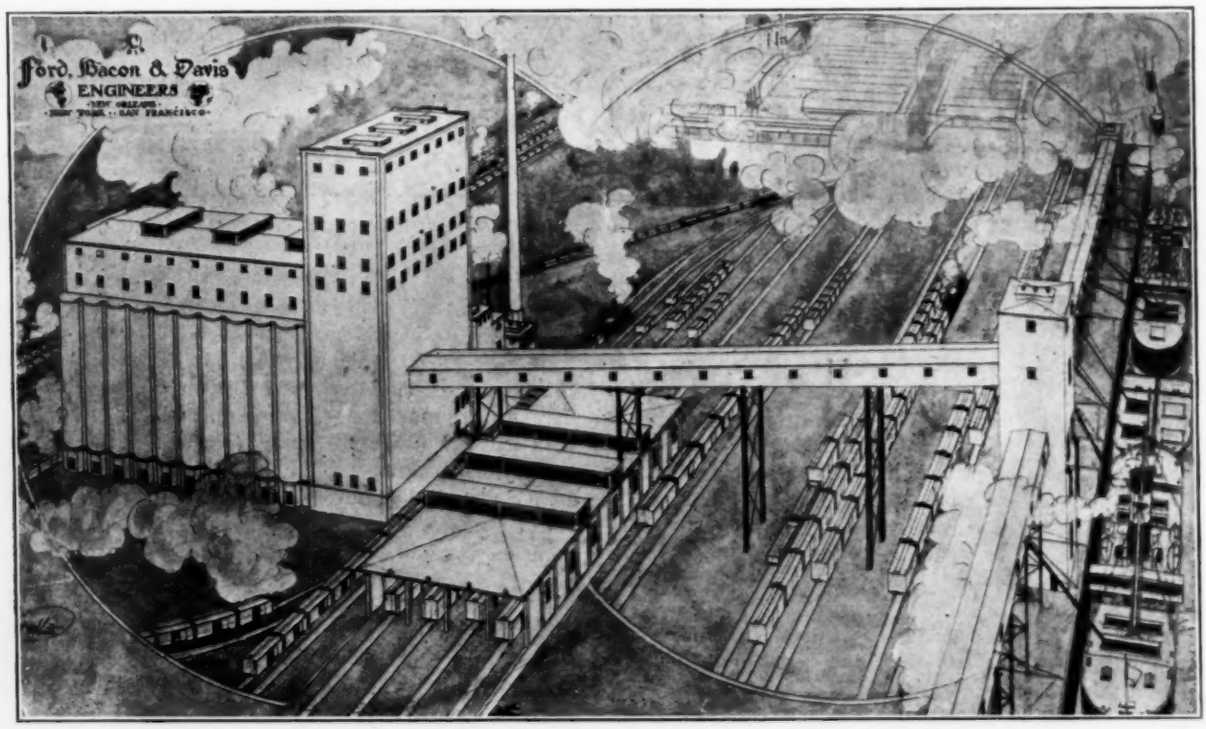


FIG. 10 DESIGN OF THE PUBLIC GRAIN ELEVATOR

driven by electricity, separate motors operating the belt, the boom hoist and a winch for shifting the barges. The feed to the belt is regulated by an oscillating plate feeding device. The coal is distributed across the barge by an adjustable discharge chute on the end of the boom. Two men operate the plant, one handling the cars and one the conveyor.

The New Orleans Railway & Light Company has installed on the wharf at the foot of Race Street, opposite their central station, a plant of 200 tons hourly capacity, for unloading coal from barges and delivering it across the shed and roadway to the storage pile.

The wharf end consists of a heavy steel tower resting on four spread columns and supporting a mast and boom with bucket and a hopper. The boom swings in a vertical plane only and slopes down and toward the river. Traveling on the boom is a two-yard clam shell bucket delivering coal into the hopper. This hopper discharges into small cars which are then weighed and hauled by cable over an elevated runway and dumped on the storage pile. The inshore end has not been completed as yet.

The U. S. Naval Station, on the west bank of the river, includes a coaling plant which is designed to take coal from

For bunkering a ship, the coal is either spouted from these bins direct into a filler at the rear of the storage house or into small cars running under the bins and delivering to the filler. The filler discharges on the main conveyor which carries the coal to the wharf and dumps it on a smaller conveyor running lengthwise of the wharf and discharging into the wharf bins or hoppers from which the ship is bunkered direct by means of chutes.

All conveyors are of the suspended bucket type and are provided with automatic weighing devices.

The wharf hoppers are fitted with small auxiliary hoppers near the tops, to which the chutes may be attached and used for bunkering in high water periods.

The storage capacity of this plant is 3000 tons. The capacity of the wharf bins is 750 tons. The hoist motor is 125 h.p.; the conveyor monitor motor 75 h.p.; the main conveyor 40 h.p.; the breaker motor 30 h.p., and the trolley motor 15 h.p.

The American Sugar Refining Company is now installing at the Chalmette refinery a small coal plant of about 70 tons hourly capacity for receiving coal from barges and delivering it into the track hoppers of the present boiler house.

The plant consists of a wharf 36 ft. by 204 ft. paralleling

the river, and on the wharf runs an electric locomotive crane fitted with a two-yard clam shell bucket and operated by an alternating current motor of about 100 h.p.

This crane lifts the coal from the open barge and deposits it in an elevated dock-storage hopper of 170 tons capacity. This hopper automatically delivers the coal to a conveyor belt by means of beaded flight feeders, actuated by a 3-h.p. motor. This conveyor, operated by a 10-h.p. motor, leads over the levee and across the road to a transfer bin of 130 tons capacity. From the transfer bin the coal is dumped into special 50-ton steel cars with hopper bottoms standing on a platform scale. Two cars at opposite points on an endless cable are hauled on a track with automatic turnout between the scale and the boiler house track hoppers.

Fig. 5 shows a typical coal storage plant, and Fig. 6 a floating coal elevator. The total capacity of the storage plant illustrated is 750 tons per hour; the hoisting engine is 35 h.p. and the trolley engine 20 h.p. The clam shell is 2-ton size.

FIG. 11 TRAVELING ELECTRIC CRANE IN PUBLIC COTTON WAREHOUSES

CAR FERRY INCLINES

On account of the variation in the river level, car inclines with adjustable tracks are required for delivering cars to the lighters or ferries. The West Side roads have four sets of inclines, the most recent installations being for the Texas & Pacific R. R., near the trans-Mississippi Terminal, and for the Southern Pacific Company at Harahan. Such an incline is shown in Fig. 7.

GRAIN ELEVATORS

There are in service seven grain elevators of standard frame construction, all owned by railroad companies, except one small elevator privately owned. The large elevators include:

Texas & Pacific:

Elevator A	350,000 bu. capacity storage
Elevator B	1,000,000 bu. capacity storage

Illinois Central:

Elevator C	350,000 bu. capacity storage
Elevator D	1,000,000 bu. capacity storage
Elevator E	1,500,000 bu. capacity storage

N. O. Terminal Co.:

Chalmette Elevator	500,000 bu. capacity storage

These elevators, except the Illinois Central Railroad local elevator C, which is assigned to local use, are all of the usual frame type, receiving grain from cars, storing it and delivering it through dock galleries on board vessels at the wharves.

The Texas & Pacific Railroad Co.'s elevators A and B are shown in Fig. 8, and the Illinois Central R. R. elevators D and E in Fig. 9.

In addition to these elevators, there are at present under construction, a reinforced concrete elevator of 200,000 bu. storage capacity, privately owned, and the Public Grain Elevator.

The Public Grain Elevator is being constructed by the Board of Commissioners of the Port of New Orleans, and is of modern type of reinforced concrete. This elevator will have a storage capacity of 1,000,000 bushels and will include some unusual features, being specially designed for rapid handling, conditioning and blending of grain. The design of this elevator is shown in Fig. 10.

It will be noted that the design provides unusual facility in the receiving of grain secured by the three distributing belts and their equipment of Mayo spouts over tank storage. The additional height required for this special equipment has been taken advantage of in providing also flexibility in distribution spouting in the workhouse, which materially increases the speed of operation.

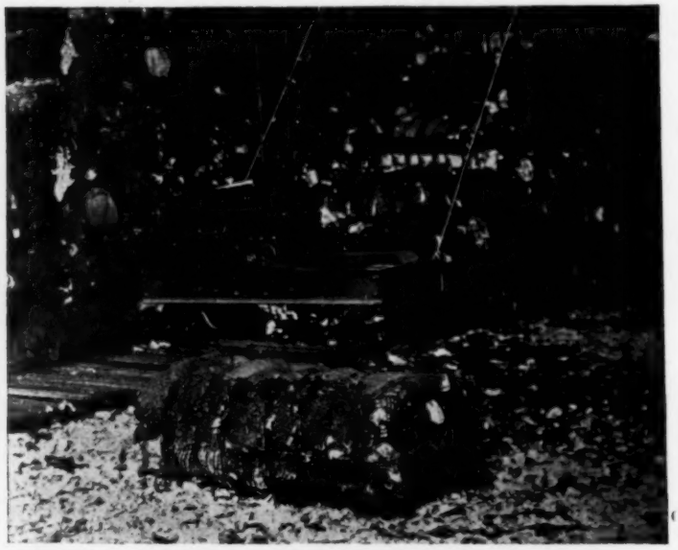


FIG. 12 AUTOMATIC GRAPPLE ABOVE COTTON BALE

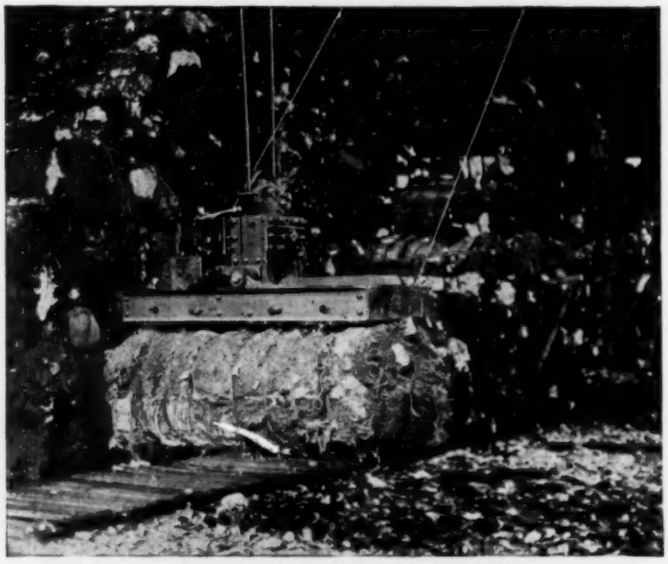


FIG. 13 AUTOMATIC GRAPPLE HOLDING BALE

FIG. 14 COTTON BALE PULLER IN POSITION

The height of the basement permits an unusual amount of the tank storage reaching each of the four shipping belts greatly facilitating the blending or mixing of grain. In addition the work house includes the necessary equipment of cross-conveyor belts, etc.

The drying plant is a distinct feature: besides having 2000 bu. drying capacity per hour, the building provides deposit space above the drier for a full day's run, which can be filled from three different parts of the storage in less than half an hour. The building also provides deposit for a half day's run below the drier.

Special attention has been given to the rapid loading of vessels, the plant as designed having four 46-in. belt shipping conveyors, with total capacity of 100,000 bu. per hour, all of which can be used to load one to four vessels at the same time.

On account of the large amount of grain accessible to the Mississippi River, the plant is being equipped with a marine tower and machinery to unload ships or barges. To more readily accommodate the great variation in water level and the varying dimensions of the vessels, a pneumatic unloader has been adopted.

In addition to these special features, the plant is provided with safety devices of latest type, including a complete dust collection system, signal systems, strand indicators, journal alarms, etc. On account of the fire proof construction and protection apparatus, it is expected that the minimum insurance rate will apply.

PUBLIC COTTON WAREHOUSES

The Cotton Warehouses and Terminal plant of the Board of Port Commissioners is of particular interest because of the cotton handling machinery with which it is equipped, and because of the consequent unique design of the buildings. The plant has an annual warehousing capacity of 2,000,000 bales and is composed of four large warehouses, a compress building and a two-story wharf house, all of the latest type of reinforced concrete construction. All of the buildings are connected by two-story runways or bridges upon which cotton is transported from one part of the plant to another.

Cotton is handled in the warehouses by high speed electric traveling cranes which are operated by one man who rides in a cab attached to the trolley. One of these cranes is shown in Fig. 11. The span is 28 ft. 6 in. The hoisting motor is 20 h.p. and speed of hoisting 150 ft. per min. The trolley speed 150 ft. per min. The travel motor is 10 h.p. and travel speed 500 ft. per min. The capacity is 2 tons.

By the use of an automatic grapple, this same operator can pick up cotton from the platforms or from trucks, and place it at any desired point in the warehouse, or can load it on a truck or trailer for transportation to the wharf. Fig. 12 shows one of these grapples above the bale, and Fig. 13 the grapple holding the bale.

Ordinary hooks are also used to some extent instead of the grapples, but require an additional man to place them on the bales. Where it is desired to remove a bale of cotton from the pile, a specially designed bale puller, Figs. 14 and 15, is used in connection with the crane. This requires the help of only one man in addition to the crane operator, but will remove any desired bale

from a tier any number of bales high in less than three minutes. The cost is 25 cents for each bale actually pulled.

The cranes can be transferred from one warehouse compartment to another on transfer tables, Fig. 16, thus avoiding the necessity of supplying a separate crane for each. The traverse motor is 6 h.p., and the traverse speed 100 ft. per min.

The cranes are of the three-motor type and are rated at two tons capacity, operating on 220-volt direct current. The hoisting motor is rated at 20 h.p. and raises the load at the rate of 150 ft. per min. The bridge is moved at a speed of 500 ft. per min. by a 10-h.p. motor and the trolley 150 ft. per min. by a 2-h.p. motor.

A compress building contains three steam presses of the usual Morse type, one having a 90-in. cylinder, one an 86-in., and one an 84-in., and a hydraulic press of 450 tons capacity has been contracted for.

Hand trucks are used to some extent in the immediate vicinity of the compresses, but, for the most part, the cotton is handled from place to place in the plant on small self-propelled storage battery trucks, Fig. 18. The speed of these trucks is 6 to 8 miles per hour, and the capacity 2 tons. The batteries have 24 cells, U. S. Lighting, 9 plates per cell. The motors are 2 to 3 h.p.

It is also proposed to employ electric tractors with trailer trains for the transportation of cotton from one warehouse to another and from the warehouses to the wharf. Each tractor will draw three trailers holding ten bales of cotton each. These trains are to be operated on the overhead runways and will travel at a speed of 6 to 8 miles per hour. A number of gasoline motor trucks with special bodies to carry 17 bales of cotton, have been provided for the transportation of cotton about the city. Two of these trucks are shown in Fig. 19. The economical speed is 12 miles per hour The capacity is 4 tons and the rated horsepower 32.4.

The wharf is to be provided with single leg gantry cranes for loading and unloading the ships. These are to be two-ton cranes of the three-motor type with a luffing or derricking boom giving a maximum radius of 50 ft. The cranes will serve the apron wharf with its two railroad tracks, as well as a second story platform of the wharf house and will take cotton from any of these places and lower it directly into the holds of the ships. They can, of course, also be used for unloading cotton from vessels and placing it on the wharf or platform, or in cars. It is possible that a continuous belt conveyor similar to the banana conveyors will be developed for the purpose of loading the vessels.

Table 1 shows the labor costs at the Public Cotton Warehouses.

LOCOMOTIVE CRANES

Several locomotive crane installations are of interest. In one plant bricks are placed in crates at the kilns, and the crates loaded on barges. On arrival the crates are removed from the barge by crane and loaded on teams or first placed in storage; the bricks remaining in the original crates from the kiln to the consumer.

Other locomotive cranes, both steam and electric driven, are used for handling sand, gravel and shells from barges to and from storage and to teams or cars.

FIG. 15 COTTON BALE REMOVED BY PULLER

FIG. 16 TRANSFER FOR COTTON WAREHOUSE CRANES

FIG. 17 STORAGE BATTERY COTTON TRUCKS AND TRAILERS

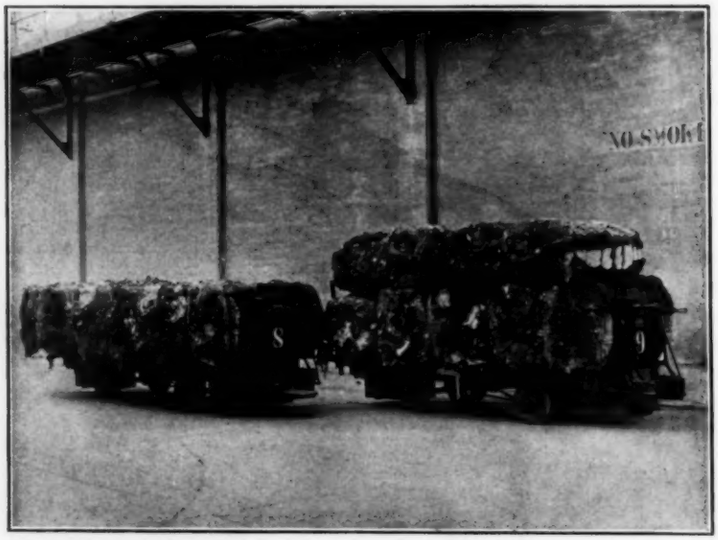


FIG. 18 STORAGE BATTERY COTTON TRUCKS

FIG. 19 SPECIAL GASOLINE TRUCKS FOR HANDLING COTTON

TABLE 1 LABOR COSTS AT COTTON WAREHOUSES

Operation		Cost in Cents Per Bale	
		Min.	Avg.
Unloading		1.3	2.
Inspecting and Sampling		2.3	3.
Weighing		2.0	4.
Compressing		6.0	8.
Band Making		1.0	1.
Trucking	Hand Trucks	...	2.
	Electric Trucks	...	1.
Storing	By Hand	2.0	6.
	With Crane	1.5	2.25
Repiling	By Hand	...	4.00
	With Crane	...	1.75
Turning Out	By Hand	2.0	7.
	With Crane	2.0	7.
Pulling Machines	Hand	25.0	50.
	Crane	10.0	25.
Ranging		...	1.5
Marking		...	0.5
Spotting (Part Output)		...	1.5
Shipping	By Trucks	...	2.5
	On Cars	...	3.0

Average Total Labor in Plant..	26 cents	Laborers paid from 20 cents to 25 cents per hour
Compressing	8 "	
Total	34 "	

Fig. 20 shows a locomotive crane handling sand from barges, Fig. 21 an electric locomotive crane handling shells from a pile and Fig. 22 a locomotive crane handling bricks in crates.

The barge shown in Fig. 20 is of 300 yd. capacity. The 2-yd. clam shell handles 250 yd. per hour.

FLOATING DERRICKS

Privately owned by individuals, the steamship companies and contractors are many floating steam derricks, Fig. 23, of various capacities, there being one each of 100, 50, 40 and 35 tons and a considerable number of smaller machines.

SAND AND GRAVEL HANDLING

Special elevators are used for unloading sand, gravel and shells from barges and delivering to storage piles. The unloader shown in Fig. 28 consists of a barge carrying a revolving crane with clam shell bucket which delivers the material to a hopper on the barge. From the hopper the material is spouted to a belt conveyor on an adjustable boom which delivers it to stock piles on shore. The clam shell is of 1½ yd. capacity and the unloader handles 150 yd. per hour.

MISCELLANEOUS EQUIPMENT

In addition to the larger equipment already mentioned, many smaller devices are in general use. Included in this class are the electric and hand operated portable cranes, electric trucks frequently with trailers, gasoline trucks, timber jacks, tiering machines, etc.

Fig. 24 shows a portable elevator, icing refrigerator cars. Fig. 25 shows a small storage battery crane truck. Fig. 26 illustrates a portable crane handling mahogany logs. Fig. 27 shows a timber jack.

DISCUSSION

W. C. BRINTON. Engineers have done comparatively little thus far in regard to freight handling machinery on harbor work. Compared with the large volume of miscellaneous freight handled, the amount of machinery in use is very small. The difficulties connected with handling freight are mostly not due to engineering. In many cases we find that customs requirements make it necessary for as many as five different organizations to handle goods between the ship and warehouse or street and freight car.

At one large terminal in New York, a large amount of freight was recently being handled five times in taking it from the ship to the freight car. First it would be unloaded from the ship to the pier. Then the weighing gang would come along and weigh it, laying it down on the pier again. Then the warehouse gang would come along with an entirely different operation, take it up and put it into the warehouse. Coming out of the warehouse there might be another weighing on account of the merchant wanting a public weighmaster, requiring a distinctly different handling of the goods from what was done by the warehouse gang. Then, if it was loaded on the freight cars, the railroad had in many cases to go through a final set of operations.

In such handling, difficulties are magnified, because it is almost impossible to put in machinery to work economically if one gang has to depend upon another. You can get a gang of men to take the material out of the warehouse, but if the weighmasters are not there the work of the weighing gang is held up.

I understand that in New Orleans there are difficulties in applying machinery because of the disagreements between the stevedores, labor unions and steamship companies. But if machinery was applied, the ultimate gain would go to the laborers in many cases. It will take considerable study and hammering on the part of engineers to get these types of machinery used so as to get the ultimate benefit possible. There is no doubt in my mind, however, that we are still in advance of European conditions in this country in handling freight.

Concerning the use of telphers, tractors and trailers and machines which will carry a load on their own backs, a very nice point to determine is which is the best type of equipment. There is no doubt that telphers will do work cheaper where you have one type of package in large quantities. If you have a long haul, with a large turning radius, tractors and trailers are desirable. If, however, you have crowded pier conditions and constantly changing kinds of commodities to haul, with fairly short hauls, a machine which will carry a load on its own back will do it more cheaply than tractors and trail-

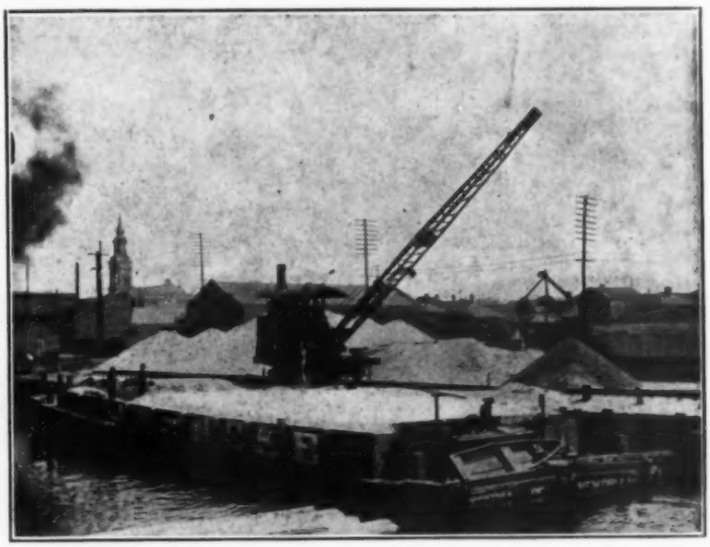


FIG. 20 LOCOMOTIVE CRANE HANDLING SAND FROM BARGES

FIG. 21 ELECTRIC LOCOMOTIVE CRANE

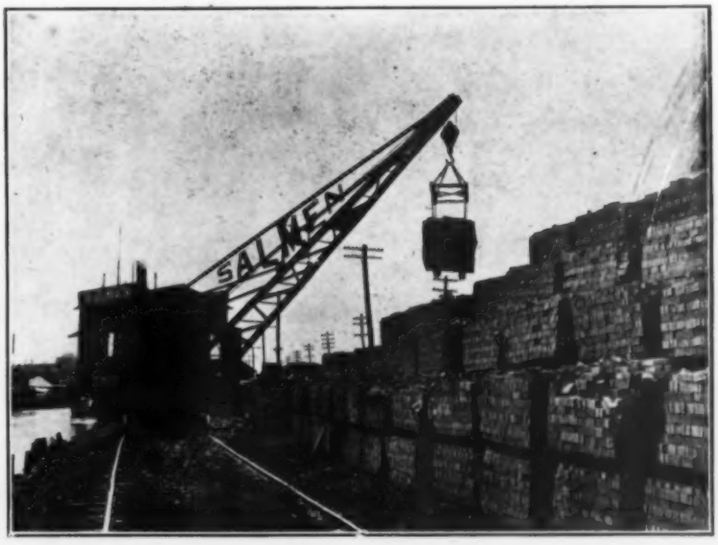


FIG. 22 LOCOMOTIVE CRANE HANDLING BRICKS IN CRATES

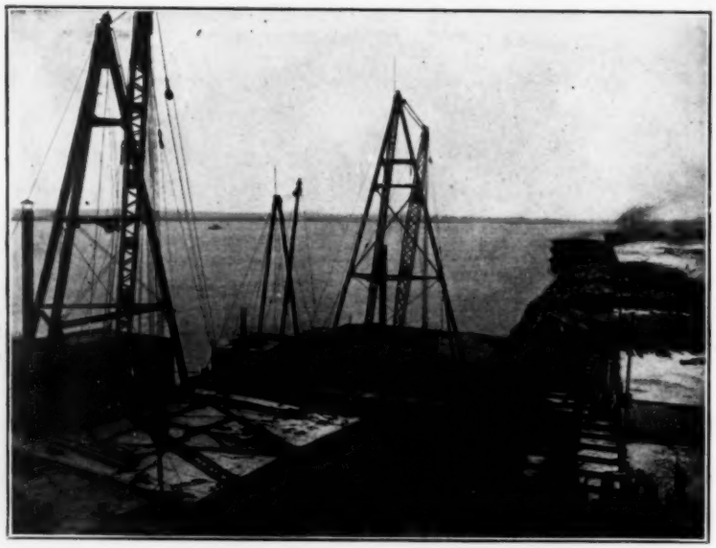


FIG. 23 FLOATING DERRICKS .

FIG. 24 PORTABLE ELEVATOR ICING REFRIGERATOR CARS

FIG. 25 STORAGE BATTERY CRANE TRUCK

ers. That must be qualified, however, by taking into account all the work, that is the labor of loading and unloading. The turning radius of the train of tractors and trailers is so great, it is almost impossible to get the trailers delivered immediately alongside of the pile.

Sometimes the problem is to keep a short turning radius, combined with a platform large enough to accommodate the bulky material used in steamship work. It is easy to make a storage battery tractor which will carry two tons, but it is not so easy to make one which will carry two tons of the kind of commodities we have in steamship terminal work without piling the material too high. If you use a bob truck, 6 or 7 ft., then in order to get on two tons of the average steamship freight, you have to pile it higher than it is economical to do with labor. If you have a platform truck, with a platform 11 or 12 ft. long—about the length that they are using on their largest trucks at the New Orleans cotton warehouses, combined with the ability to raise separate plank platforms by a power raising mechanism, you can get the combined advantages of tractors and trailers and a machine which will carry a load on its own back. That must be done with a machine of a uniform turning radius, because there is allowed a fairly large turning radius for all the places where they are using tractors and trailers and the tractors and trailers can be left outside of the buildings and the goods picked up with a crane for removal to the different compartments. However, on many classes of hauls it would be cheaper to do the work with separate plank platforms and pick up the platforms. The machine will then not be delayed while loading and unloading the platforms.

On miscellaneous steamship freight such as we have along the river front in New Orleans and in New York, there is no doubt that the separate plank platform with a machine which will pick up the plank platforms, will do the work cheaper than the tractors and trailers, due to the fact that you have no difficulty in getting the loading done immediately alongside the pier.

FRANK B. GILBRETH. In this matter of devices for handling materials at docks, I want to call attention to the use of gravitation for this purpose. I have been advocating such use for many years, and my successful experience with gravitation as a transporting force will perhaps make my findings on this subject of some value.

Many years ago we utilized this force by inventing a gravity concrete mixer, the principle of which is now being widely applied. We were also the first to transport concrete long distances by gravitation from a large sheet metal pipe, the lower end of which could be swung over a large area. This was the first use of the invention of "spouting," or conveying the concrete long distances by gravitation. It was ahead of its time. To-day practically all large jobs of concrete are "spouted."

The efficiency of gravity as a transporter and of handling materials in different parts of a building

by simply hoisting them and having them descend by gravitation on roller conveyors has been demonstrated time and again. The cost of this method is low. Yet in spite of these facts not over one tenth of one per cent of all buildings under construction use roller conveyors for transportation purposes. In the public cotton warehouse described horizontal transportation is being done by trucks. This is inefficient and is wasteful of both time and money. The vertical transportation of material at docks costs very little comparatively, for the reason that it can easily be systematized, standardized and controlled. Handling materials at this public cotton warehouse by hoisting vertically by power and distributing horizontally by gravitation would reduce the cost to a point that would be surprising.

A further reduction of costs could be secured by standardizing the handling devices, but the first step is an appreciation of the unusual force, of the availability, and of the efficiency of gravitation as a transporting force, and of the advantageous by-products, as well as products, of its utilization.

JOHN R. FORDYCE did not wish to discuss any feature of the port equipment described except the cotton handling warehouse. He said that no doubt the warehouse met all the conditions which had to be contended with, but he would like to give the results of some of his own experience in cotton handling.

Cotton Storage and Piling.—The compartments are designed so that four rows of bales are arranged with two open aisles, to enable access to the ends of each bale, so that any bale can be pulled out of the piles, and also that water from the sprinkler above can reach the origin of any fire. The height of the compartments are I believe approximately 35 ft. from the floor and the compartments near the wharf are to be 40 ft. The two piles of bales that lean against the wall can doubtless be carried up to twelve bales high, or about 20 ft., without fear of toppling over, but the two piles in the center which lean on each other cannot safely be carried up more than eight bales high or about 14 ft. (I assume the thickness of a compressed bale as 20 in.) Even at this height it will be hard to get a bale out of the lower tiers of the side or wall piles because of the great weight above and the rough and uneven character of the bales. The pull of the ropes of the bale-puller will throw the pile over against the wall and the pile will of course not fall down, but if this same operation were tried on the middle piles there would be danger of the whole pile being thrown over. In case many bales had to be taken out, the piles would no doubt have to be repiled, as the holes, unless filled, would cause the collapse of the pile. A system of jackscrews working from the floor could raise the weight of the bales above and enable the lower bales to be pulled out just as easily and cheaply as the plan described.

The overhead electric crane, while ideal for machine shops and other places where the packages have to be carefully handled and placed, does not seem to me to be the best thing for cotton handling.

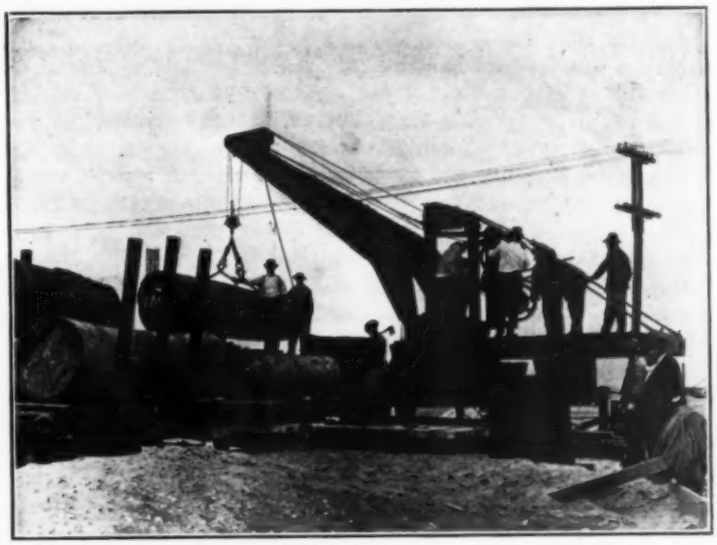


FIG. 26 PORTABLE CRANE HANDLING MAHOGANY LOGS

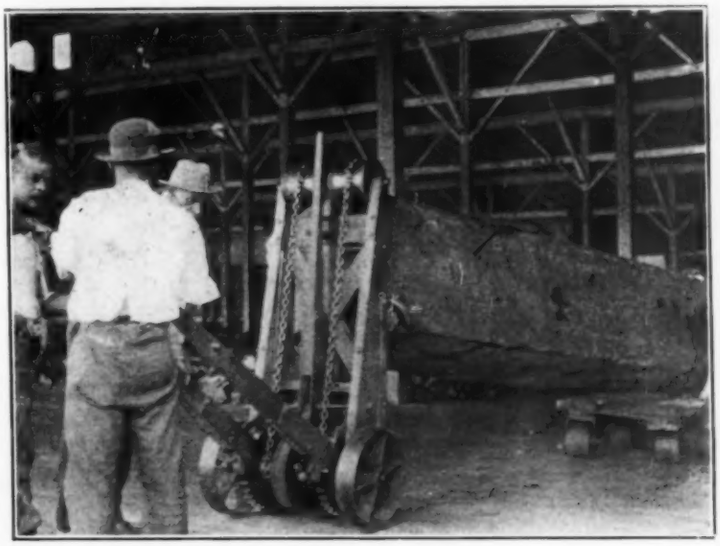


FIG. 27 TIMBER JACK

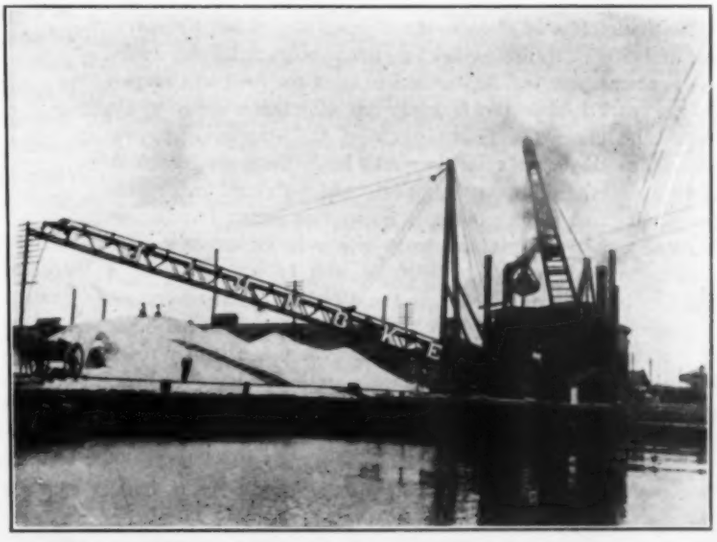


FIG. 28 FLOATING ELEVATOR UNLOADING AND PILING SHELLS

However, I realize that if this warehouse system is likely to be used for other commodities, then the cranes and the high warehouses will probably be ideal. For cotton, however, you have wasted at least one third of the height of your buildings, expense of preparing your craneways, power plant, crane transfer structure and maintenance of the cranes. The cost of these is out of proportion to the benefits gained, in handling a slow moving, non-damageable package such as a bale of cotton.

Assuming that 20 ft. is the practical height of a pile of cotton. A building 25 ft. high would give ample room and clearance for the automatic sprinkler, and an elevator working from the floor of the aisle would hoist bales equally as well as overhead cranes, and at the same time could be arranged to lift off the weight of the bales above the one which was wanted. Thus the additional cost of building the runways and all the attending apparatus would be saved and a cheap elevator used which could be dragged in and out of a compartment much quicker than a crane could be. Another and far more serious objection to the overhead electric crane is the danger from fire. I tried an overhead monorail hoist over cotton in 1901 in Little Rock, Ark., and had to abandon its use because it set fire to the bales below. I understand that several fires have already occurred in these New Orleans warehouses, and have before me a pamphlet issued by the Louisiana Fire Preventive Bureau which attributes the cause to defective mechanism in the cranes, which no one of course foresaw. Even if these are corrected others may develop and I believe the only safe way to do it, is not to try to use electricity in overhead apparatus. Overhead apparatus operated by cables similar to aerial trams can be applied and the winding engines kept on the outside of the compartments. I have devised one for the warehouse in Galveston, where the sheave runs on a rope so that the entire strain is taken off the roof, which is too light for any increased weight. This rope can be shifted from side to side in the bays and thus come over any pile of cotton. The bale of cotton can be dragged back and up over a pile of bales when no aisles are left, which sometimes occurs in congested times. This whole apparatus is cheap and can be carried out of one compartment and erected in another in a short time and at little cost. The necessary rings and hooks which have to remain in a compartment holding one thousand bales cost less than $50.00, so that the amount of money locked up when the compartment is full or idle and not being worked is a minimum.

Transportation of Bales.—Mr. Brinton stated that the carrying of bales by trailer pulled by electric storage battery tractors is not as practical or economical as if the load was carried by the truck itself. Mr. Gilbreth has said that a slight grade should be given the roadways from the warehouse to the wharfs, as the loads were always to be in the same direction. Here again the designing engineers had no doubt to provide for goods from ships moving in as well as cotton from warehouses moving out. I have had quite a lot of experience in handling cotton by trolley systems, and have found that a slight fall of 6 in. per 100 ft. in the direction of the movement of the cotton is a great help. In Memphis, Tenn., in the plant of the Memphis Terminal Corporation, there is a trolley track with that fall on which one mule can push one hundred bales of cotton in one string of trolleys. His work in one day at that rate would be the delivering of 4000 bales in ten hours over an average distance of half a mile. A system similar to that could be applied very easily in the New Orleans plant for you already have all the headroom needed. The bales hoisted out of the compartments on to the upper runways by the overhead cranes could be dropped on a roller platform which could be easily moved along opposite the opening of each compartment. The trolley track running along the outside of the posts could have the required grade and the bales hung on to the trolleys as they were rolled past this roller platform. They could then be gathered into strings, and pushed over to the wharves by tractors. The same tractor which could pull four trailers loaded with six bales each or twenty-four bales in all, could push one hundred bales if they were hung from trolleys. The empty trolleys could be returned to the warehouses along the outer runways and hoisted to the upper levels by inclined moving chain elevators such as are used in packing house practise. This system could be easily designed to carry other commodities than cotton and to work both in and out with loads.

In submitting these ideas I realize fully that it is much easier to criticize than to originate and that not knowing all of the conditions which had to be considered by the designing engineers I may have of course arrived at a different conclusion from theirs.

The taking advantage of the pull of gravity wherever possible for moving materials is, however, a subject worthy of careful study. It has worked wonders in other places and should be considered here.

GARDNER T. VOORHEES. One of the biggest things that I have seen at this meeting was the warehouse receipt of the public cotton warehouse, and I think this has an immense value as a negotiable matter. I am confident that a similar receipt on the very valuable goods that have to go into cold storage would have an equally great value, although, of course, the goods that go into cold storage, more particularly in the North, the butter and eggs, form the big things on which money is loaned by the banks. But in the future a warehouse receipt, having the city and the state both back of it, the same as the cotton warehouse receipt inaugurated in this port, would, I believe, be of great value to the users and producers of any material passing through cold storage.

GEORGE H. DAVIS, who presented the paper in the absence of the author, emphasized the point that the handling machinery of a port is not an engineering problem entirely. It is possibly 25 per cent engineering; possibly 25 per cent business, 25 per cent policy in running—as to whether this will be acceptable or that will be acceptable—and 25 per cent miscellaneous. While the machines themselves are simple, and such that a casual observer would think ought to be used everywhere, as a matter of fact, it is rather difficult to establish machinery handling through a port of this kind. The matter is one of slow development, and the slowness does not come from the engineering side, but from other sources.

Experiments have for some months been under way for the production of a high-speed tool steel which will equal any at present on the market, but which can be easily made without the use of alloys dependent upon components of limited supply, such as tungsten and molybdenum. Such an alloy has been produced. The melting is done in an ordinary crucible furnace capable of high temperatures, and the steel is then cast to the desired form in either metal or sand moulds. When cold, the tools, without any forging or heat treatment, are ground on an emery wheel (dry) and finished on a wet grindstone. As the tools possess the correct hardness, various skilled operations are eliminated.—*Engineering*, May 26, 1916.

A NOVEL METHOD OF HANDLING BOILERS TO PREVENT CORROSION AND SCALE

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Non-Member

THERE will be described in detail a radical departure from the conventional methods of handling boiler troubles due to corrosion. At present the method considered most highly scientific is to send samples of water to a chemist in order that a proper corrective may be prescribed. The composition of the corrective is usually a trade secret, jealously guarded, which the purchaser uses blindfold. On the other hand, the method to be described applies one corrective to all waters. A different composition of feed water demands not so much a different composition of corrective as a different quantity thereof. A simple chemical test, made by the engineer of the plant, or his clerk, gives the condition of the water *in the boiler, under steaming conditions,* and determines the quantity of chemicals to be applied. The purchaser now works with his eyes open.

It seems from all that can be ascertained at the present time, that at least there is a method of handling boilers, with a compound applicable to any water under any conditions of steaming, without a material change in the formula. The only requirement is that the boilers must be treated individually; it is not enough to treat a battery, or to treat the feedwater going into the boilers in general.

The first application by the author of this method was made at the Fruitvale power station of the Southern Pacific Company, the boiler equipment of which consists of twelve water tube boilers, each of 645 boiler h.p. It has since been used by the Southern Pacific Company in stationary plants in the oil fields and on locomotives in the same district.

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The method is in no respect original with the author. It has been his good fortune to be able to apply the work of another who was similarly situated, but who solved the problem for himself. The results have been such that it seems worth while putting them on record, particularly since a description of the method has lain in the technical literature of this country unnoticed for about three years. Apparently it has attracted almost no attention outside of a very limited circle.

The first inspection of the boilers of the Fruitvale plant after it was put in operation showed that serious corrosion began a very short time after the plant was started, although the boilers were not on regular load. The ordinary remedial measures produced no results at all. Bearing in mind that the plant was put in service to haul trains in the fall of 1911, it is significant that by June, 1912, the feed elements of the boilers were all in serious condition. With a total of 3360 tubes in all boilers, 252 tubes were requisitioned for replacement during practically the first eight months of operation. By the end of July, 1912, the trouble was extending to the second row of tubes, and 250 more tubes were requisitioned to take care of the trouble. In September, inspection showed that the drums were being attacked. In October, boilers Nos. 1 and 3, after having been equipped with new tubes and placed in service in August, and worked entirely with water treated by the lime process, were found to be pitted worse than ever, and this was after the first serious effort to treat the water had been put into effect. In November, 1912, the piping was modified according to a plan sent by the manufacturers of the boiler, but in December of that year the inspection showed the pitting

SYNOPSIS OF PAPER

This paper gives an account of experiences with a method of preventing corrosion and scale formation in steam boilers, which differs from the commonly accepted theory of boiler water treatment in that a high alkalinity is carried in the boiler. It has been commonly considered that a boiler water high in alkalinity has a decided tendency to prime, and this is probably true if no anti-priming substance is added. Under the high alkalinity treatment described, boilers have been run with no corrosion for more than a year, and the normal alkalinity has frequently reached 10 per cent without any tendency to prime.

The treatment was first applied by the author to twelve 645-h.p. water tube boilers at the Fruitvale power house of the Southern Pacific Company, California, which presented one of the most pronounced cases of localized corrosion on record. At the time the treatment was commenced, all other known methods of treatment, including observation for electrolysis, had failed to stop the corrosion, which became so serious that eighteen months after the boilers were put in service one-third of the tubes had been replaced.

The treatment consists in adding to the hot-well water a compound known as the Navy Standard Boiler Compound, originally developed by Lieut.-Com. Frank Lyon, U. S. N., as the result of numerous investigations and experiments on the corrosion of boilers and piping. The ingredients of the compound are sodium carbonate, trisodium phosphate, dextrine or starch, and a tannin compound, such as cutch. The sodium carbonate is the main ingredient and is used to take care of any chemical reactions and render the solution non-corrosive. The tannic acid and starch throw down the scale-forming compounds present in ordinary feed water. The trisodium phosphate prevents the rise in surface tension of the solution and consequent priming which would be caused by the original impurities in the water and by the application of the other ingredients in the compound. In using the compound to prevent corrosion a sufficient quantity must be added to the water of each individual boiler to render the alkaline strength of the solution 3 per cent normal or above.

The use of the compound at Fruitvale resulted in almost complete cessation of troubles from corrosion. Two months after the first boiler at the station was placed under treatment, the tube replacements were reduced from 171 per month to zero, and the labor and material costs were correspondingly reduced from over ten thousand dollars a year to twelve hundred. There is no scale in the boilers; they are absolutely clean. Below the water line they show clean black iron; above a thin coating like whitewash.

The results were so satisfactory that the method was extended to locomotives in service in one of the worst locomotive water districts on the Southern Pacific Lines, and to other power plants of the company's system, all with favorable results. In one particular case, the water carried 230 grains per gallon of solid matter and nearly every known variety of boiler trouble had been experienced, but the compound eliminated corrosion and precipitated the solids in a soft, slushy form easily washed out.

The Associated Pipe Line is using the compound successfully in twenty-six stations in the San Joaquin Valley, chiefly for the prevention of scale. Most of the stations have three 250-h.p. water tube boilers and use water containing solid matter varying in amount from 5 to 231 grains per gallon. In places where the solid content is so very high it has been necessary to increase the quantity of anti-foaming chemicals above that ordinarily contained in the compound. This has been done, not by changing the composition of the compound, but by adding separately a quantity of the non-foaming ingredient, trisodium phosphate.

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to be very severe, and in January, 1913, 300 more tubes were requisitioned. This made a total of 1050 tubes in a year and a half, not counting about ninety which were put in by the manufacturers.

About this time began the use of a compound furnished by one of the best known companies in the business. The result was apparently to transfer some of the trouble from the tubes to another part of the boiler where there had been no trouble before. A sediment of black mud formed a scale which caused blisters and tube failures at those points. In June, inspection showed bad corrosion and pitting in all parts of the boiler, and 960 tubes were requisitioned. By October, 1913, the total work orders for boiler repairs on that plant amounted to $16,000, or nearly 12 per cent of the first cost of the boiler plant. Three different special formulae for compounds submitted by the same chemical company had been used, but as things were going from bad to worse, the use of the special compounds was discontinued.

In the fall of 1913, with a fine steam plant in a very critical condition, 1160 tubes out of 3360 had been replaced and there was no end in sight. A new expert was called in, who began by suggesting the conventional methods of zincs and paints, and that perhaps electrolysis was to blame, although everything had been kept carefully insulated. The result was no better than before.

THE NAVY STANDARD BOILER COMPOUND

About that time the author was handed the August 1912 number of the Journal of The American Society of Naval Engineers, which gave an account, by Frank Lyon, Lieutenant-Commander U. S. Navy, of what seemed to be a highly significant development in boiler trouble treatment.[1] In the course of his article, Commander Lyon said: "The writer has no hesitancy in saying that any boiler, using any water, can be kept from corrosion for any length of time." Having been brought up to understand that whatever a Naval officer says is so, without qualification, the salvation of the Fruitvale boiler plant appeared to be within reach.

The result of Commander Lyon's investigations was the development of the Navy Standard Boiler Compound. This compound is composed of sodium carbonate, trisodium phosphate, starch and tannic acid. The sodium carbonate takes care of any chemical reactions and renders the solution non-corrosive. The tannic acid and starch are added to prevent the formation of scale, the action being to hold the impurities in suspension in a colloidal state. The trisodium phosphate prevents the rise of the surface tension of the solution and consequent priming caused by the impurities in the water and by the application of the other ingredients in the compound. In using this compound to prevent corrosion a sufficient quantity must be added to each boiler to render the alkaline strength of the water in the boiler 3 per cent of normal or above, and the alkaline strength must be maintained in *each* boiler.

The compound may be purchased from the Government Contractor[2] for about one-half the cost of the ordinary compounds. Various proprietary companies also supply essentially the same material under their own trade names, but at about ten times the price of the real article.

[1] Navy Department, Washington, D. C. $1.30 postpaid. Reprints of the article are also available.

[2] Through the courtesy of Commander Lyon, the Society is informed that the compound has been made up by Bird, Archer & Co., 209 Washington St., New York, and Lord & Company, Philadelphia.

USE OF THE NAVY COMPOUND IN THE BOILERS OF THE FRUITVALE STATION

On the 4th of March, 1914, the first boiler was placed under treatment with the Navy Standard Compound. By the 26th of March it was in use in all of the boilers. As illustrating the results, the record of tube replacements month by month is most significant. In 1912, 690 tubes were replaced; 858 in 1913. In January and February of 1914 there were 229 tubes replaced in the two months, or at the rate of 1374 a year. The treatment, as stated above, was begun on the 4th of March, and was in all the boilers on the 26th. Thence the record stands: In February, 171 tubes replaced; March, 24; April, 15; May, 2; and from May 1914 to June 1915 (date of writing), not one has been replaced for failures. There have been 13 tubes replaced since May 1914, but they have all been replaced because they had to be taken out to get at something else, or by reason of obvious defects.

As to the money saved by the introduction of this method: In 1912 it cost in labor and material $5790; in 1913, $10,256; in the first six months of 1914 it was $1579, and since then the expense will hardly come to a hundred dollars a month for everything considered, that is, the ordinary wear and tear of the plant, washing of boilers, etc. In addition to this, extra labor in the plant (made necessary by the failing tubes), to the extent of $181 a month, has been discharged. The treatment as practised there costs about $80 a month, depending upon the amount of compound used. There is no scale in these boilers; they are absolutely clean. Below the water line they show clean black iron; above, a thin coating like whitewash.

USE OF THE NAVY COMPOUND IN LOCOMOTIVE BOILERS

The first two months' operation at the Fruitvale power station with the Navy compound in use showed such very satisfactory results that the management ordered a trial of the method on probably one of the worst locomotive water districts in the company's service, namely, that part of the San Joaquin Division between Bakersfield and Mojave, known generally as the Tehachapi Pass. Mr. R. S. Twogood, assistant engineer in the office of the consulting electrical engineer, was detailed on this work and for nearly a year he has given practically his entire time to this demonstration. The following is an abstract of his contribution to the discussion at the December (1914) Meeting of the San Francisco Section of the Society, when this subject came up for a general discussion.

On July 21, 1915, a compound test was started on freight Mallet locomotive No. 4031, operating over the Tehachapi Pass. The locomotive was just out of shop. It had a new set of flues, was free from scale, with the exception of a thin deposit on the crown sheet and crown and stay bolts that were not removed during back shopping. The engine was left in chain-gang service.

At first an effort was made to carry the alkalinity at 3 per cent, but so far the best results have been from 0.5 per cent to 0.7 per cent normal alkalinity. Several things in the design of the locomotive, especially the Mallet, contribute to this result: for example, a very small steam space and steam dome; no perforated dry pipe to collect steam from all parts of the boiler; constant surging of the water due to the motion of the locomotive; sudden opening of the throttle and consequent great demand for steam, which reduces the pressure on the surface of the water under the throttle and causes it to rise and pass over into the steam pipes. Also, the water used for loco-

motive purposes in this district contains a large amount of solid matter which would tend to cause priming.

One point constantly in mind was to find some treatment in which one man could be made responsible, without having to depend on the engineers and firemen. This means that the boiler must be treated at engine turning points.

At first the chemicals (enough for the entire trip) were put into the tender tank, thence to pass with the feed water through the injector, feed-water heater and into the boiler. By this method the desired percent of normal alkalinity in the boiler was not reached until one tank of water (10,000 gal.) had been used. Also, considering the fact that the tank capacity is much greater than the boiler capacity, the tank alkalinity was very low. This low alkalinity, though strong enough to bring out some solid matter, did not furnish sufficient tannic acid and starch with the standard proportion of chemicals to prevent this solid matter from forming scale. In the injector, where the cold water came in contact with the steam, and later where the warm feed water came in contact with the hot boiler water, some scale was formed. After this was noticed no more compound was added to the tank, but was pumped, in a concentrated solution, through the injector. This gave at once the desired percent of normal alkalinity in the boiler. There has been no further trouble with scale.

The water from Bakersfield to Mojave averages about 3 lb. of scale-forming matter per thousand gallons. A Mallet locomotive in a helper trip from Bakersfield to the Summit and return will use from 30,000 to 35,000 gal. of water, which means about 100 lb. of scale per helper trip. With the present method of treating, 20 lb. of compound are pumped into the boiler before leaving Bakersfield yards. This gives an alkalinity of about 0.6 per cent, and as this percentage remains approximately constant between engine turning points, it is possible to treat the boiler for an entire trip before it leaves the roundhouse.

If too little compound is used the precipitate is fine and does not settle readily; but when the amount is sufficient the precipitate is large and flaky and settles very rapidly. This makes it easy to clear the boiler of some of the solid matter by blowing down after the engine has been standing on the siding a few minutes awaiting passing trains.

Present practice is to wash the boiler every second trip. A large percentage of the solid matter runs out with the water while draining the boiler and the rest is easily washed out. The solid matter has no tendency to cake, but will remain indefinitely in the form of a soft brown mud. It must be borne in mind that the frequency of washing is a function of the amount of solid matter in the water and the amount of water used.

Prevention of corrosion and scale formation was the main endeavor and yet another result was obtained, just as important. Absolutely no boiler troubles were encountered during the first four months of the test, and then the record was broken only by a minor leak, a record that gives some idea of the importance of keeping the boiler free from scale and thus prevent the high and uneven temperatures in the steel which cause the opening up of joints.

It is standard practice to carry from 1000 to 1500 lb. of sand on a Mallet locomotive to cut the soot from the inside of the flues. Why is it not just as important, for good steaming, to use some method to keep the outside of the flues free from scale?

The ingredients of the Navy compound originally were proportioned for use in stationary and marine boilers, and at an alkaline strength of 3 per cent normal. The 10 per cent of trisodium phosphate was added to prevent light water. The locomotive type of boiler, in general, shows a greater tendency to foam than other types of boilers and should, therefore, have a stronger non-foaming reagent. In cutting down the alkalinity from 3 per cent of normal to less than 1 per cent, the amount of trisodium phosphate has been greatly decreased with good results. The amount required seems to vary so much with different runs and conditions that as yet no decision can be made as to a definite amount for general use.

A new water was obtained at Bakersfield in January that is a great deal better than the old, as far as content of incrustating matter is concerned, but it is very light. Foaming and priming became so bad in one of the passenger locomotives that the water in the glass rose as much as 8 in. when the throttle was open. No compound of any kind had been used in this boiler. Six pounds of trisodium phosphate (no compound) was then put in the boiler through the injector just before the engine left the roundhouse for each trip. There has been no foaming on this locomotive since.

During the early part of the test on Mallet No. 4031 some light water and foaming were experienced. It was feared at that time that water, passing over, would loosen superheater units and high-pressure steam piping, and would cut cylinder bushings and packing, but these fears proved to be ungrounded. The engine has made more miles between shoppings for boiler repairs than any other Mallet operating out of Bakersfield.

On this division, where the water is poor, practically all of the locomotives are back-shopped on account of the boiler and not the machinery. The present indications are that the use of this compound will make the life of the boiler longer than that of the machinery.

During the last month the use of this compound has been extended to all freight Mallets (seven) operating out of Bakersfield. Some of these had been in service for several months and large quantities of scale had formed. The cutting of this scale made very dirty boilers, causing frequent blowing and boiler washing. After two or three weeks, scale from $\frac{1}{8}$ in. to $\frac{3}{8}$ in. thick came off in large quantities, which proves that the compound will cut the old scale, but this action causes such dirty boilers that such procedure cannot be recommended. By the practice outlined above, a clean boiler can be kept clean and operated with success, using water classed by boiler people as very poor.

USE OF THE NAVY COMPOUND IN STATIONS OF THE ASSOCIATED PIPE LINE COMPANY

The results in the Fruitvale power station boilers caused prompt steps to be taken to extend the use of the compound to other stations either operated or controlled by the Southern Pacific Company.

The Associated Pipe Line Company operates an oil pipe line from the oil fields in the southern end of the San Joaquin Valley to tidewater near San Francisco. On this pipe line are 30 steam pumping stations equipped, some with three and some with four 250-h.p. water-tube boilers. The feed water is of practically every known grade from good to very poor, and nearly every known type of boiler compound has been used from time to time in the worst of these stations. Mr. E. B. Partridge, Jr., superintendent of the pumping plants in the fields, came to Fruitvale power station for a study of the method. He began his investigation in the most

skeptical frame of mind and he introduced the compound first into a station where, as he said, it could do the least harm. Eight months later, at the December meeting of the San Francisco Section of the Society, where the subject was discussed, he gave an account of his experience which is here briefly summarized: In the thirty different pumping stations there were thirty different kinds of water, with a solid content running from 6 to 230 gr. per gallon. In the first station, a three months' trial of the compound showed that a turbine tube cleaner was no longer necessary, because the boiler was readily washed out and cleaning would not be required oftener than every three months.

These results were confirmed at the next station where the compound was tried. It was then introduced in a station which most of the feed-water experts in the State had turned down as impossible. The water carries 230 grains to the gallon. In these boilers 2½-in. extra-heavy boiler blow-off nipples corroded away in from three to four months and 3-in. extra heavy feed-water lines pitted through in the same length of time. Nearly every known variety of boiler trouble had been experienced at this plant, but the Navy compound eliminated corrosion and precipitated the solids in a soft slushy form easily washed out. Owing to the unusually large quantity of solid matter in the water, however, it was necessary to blow the boilers every hour and to clean every ten days.

At another station where corrosion very similar to that in the Fruitvale boilers had been experienced from the start and all kinds of compounds had failed to relieve the trouble, the Navy compound was introduced. Up to that time they had used No. 9 gage seamless tubes in the bottom boiler rows, and No. 10 gage special spellerized tubes in the upper rows, but none of them lasted more than three months. Feed lines, blow-off pipe lines, boiler drums and headers, together with the tubes, were all affected by corrosion; but the Navy compound straightened out all their trouble in this station precisely as in all the others. In order to have further verification, pieces of new tubes were hung in these boilers and after three months they showed not the slightest signs of corrosion.

In general, Mr. Partridge found that when he commenced to use the compound there were a great number of tubes which had been badly pitted and that these failed gradually, but they held up surprisingly well, considering their condition. Only a very few of these old tubes have been lost and none that were put in just prior to the introduction of the Navy compound treatment. He found that to get results it is necessary to work intelligently and not at all in the old haphazard fashion. He detailed an inspector on the work who travels from station to station, not only to see that the compound is being properly used and in sufficient quantity, but also to instruct engineers and to quiz them as to the results they obtain.

At every pumping plant a printed form is filled out and mailed to the general office every morning. From these Mr. Partridge keeps a close supervision over all of the plants. The reports show how much compound is used; what percentage of alkalinity is carried; how often the boilers are blown, that is, a bottom or a surface blow; when any particular boiler is cut in or cut out, and why; and the condition of the boiler when it is opened for cleaning. The importance of these results is best understood by engineers who know the operating conditions of an oil pipe line, where all the pumping plants are in series from one end of the line to the other, and a delay or a stoppage at any one station affects the output of the entire line, and consequently the earning capacity of the whole property.

USE OF THE NAVY COMPOUND IN SOME VESSELS OF THE U. S. NAVY

The use of the Navy Standard Boiler Compound was discussed in a preliminary way at a meeting of the San Francisco Section, after which it was suggested to the author that it would be well to go slow in using Navy compound, for the reason that some vessels had experienced such serious damage to their boilers from it as to cast discredit upon this method of boiler treatment. The substance of the statement was that for some years evidence has accumulated to show that under certain circumstances the use of sodium carbonate or sodium hydrate in boilers makes the steel brittle and causes failure of the joints by cracks; that at present it is impossible to state how or why the action occurs, but it is possible to name the circumstances under which it is likely to occur, the characteristics of the cracking when it does occur, and the principal cases that have come under direct notice.

Briefly, the theory advanced to the author as to the trouble is as follows: That sodium carbonate is always partially converted into sodium hydrate when in solution under boiler temperature, so that it makes no difference whether the carbonate is used in the beginning, or caustic soda, or both, as sodium hydrate will always be present sooner or later. When either of these substances is used for the treatment of scale, no trouble from the cracking of the steel is likely to occur, because they react with the scale and there is little or no excess hydrate. Where cracking has occurred it has always been true that free hydrate has been present in the boilers in the absence of sulphate; so that the statement is warranted that whenever sodium carbonate or sodium hydrate is introduced into a boiler in the absence of substances reacting with them, brittleness will result sooner or later. Cases have been known in which the brittleness approaches that of neat cement of the same thickness as the plate. It occurs only in the seam of the boiler, either due to the fact that the joints are at higher stresses here than in the rest of the plate, or that the joints are the only place in which this solution can concentrate, and it is known that unconcentrated solution does not attack steel at all. The cracks that result are distinguished from ordinary forms of cracking by the following characteristics:

They are more fully developed at the surfaces of the contact of the joints than they are at other surfaces, so that a crack at a rivet hole will often measure ¾ in. on the contact surface of a ½-in. plate without showing at all on the other surface; in other words, the surface of the crack itself is usually triangular, with the base of the triangle on the contact surface. They usually originate at the rivet holes and show scarcely any tendency to follow the lines of stress. Running from adjacent rivet holes, two cracks will often pass each other and after passing, join, leaving an island in the plate; that is, the cracks show no strong tendency to join each other. They change their direction sharply and often, to an extent of 90 deg.; they are always unaccompanied by any elongation of the plate; and finally, they are always, of course, below the water line.

The statement made to the author gave also a number of cases of such defective plates. Among others were named the boilers of the U. S. Torpedo Boat Destroyer *Aylwin*, wherein occurred a fracture of one drum, and cracking of one or more drums of three boilers out of four; also the U. S. Coast Guard Cutter *Unalga*, where a cracking of one drum out of two in a period of operation of about fourteen months was noted. The statement concluded by a note to the effect

that in the case of the Coast Guard Service, an order had been issued discontinuing the use of the Navy compound.

Because the treatment, at least in this form, originated in the Navy Department, because the *Aylwin's* boilers were cited among others as having failed from this cause, and because the Navy boilers are operated in general with water that is practically free from sulphates, the statements with reference to Navy experience were investigated as fully as possible, and the following facts were developed:

The use of Navy compound has not been discontinued in the Navy, but the compound is used ordinarily only in sufficient quantity to maintain the water in the boiler at a low alkaline strength, and not above ½ of 1 per cent normal, the point at which corrosion changes in character from general corrosion to local corrosion or pitting. In a steaming boiler no difficulty is experienced in maintaining the alkaline strength of the water at or above 3 per cent normal; but naval boilers are idle during a large part of the time, and owing to the fact that the compound does not remain in solution in idle boilers, but settles to the bottom, the alkaline strength of the water in the upper part of the boiler frequently falls between the limits of 1 per cent and 2.5 per cent of normal. As is well known, the effect of this alkaline strength is to promote corrosion in its most dangerous form—local corrosion or pitting.

The early experiments with the boiler compound determined the facts that good steel will corrode almost evenly over its entire wetted surface when placed in distilled water, and that as boiler compound is added to give the water a low alkaline strength, the rate of corrosion is somewhat decreased, but the character of the corrosion remains the same. Therefore, low alkalinity inhibits all but a light general corrosion, which is so small in amount that its effect may be disregarded for practical purposes.

Further, since the Navy uses distilled water to a large extent, only small quantities of scale-forming substances are ever present in the boilers, and hence large amounts of boiler compound are not required to prevent the formation of scale.

In the case of the *Aylwin's* boilers the Naval Engineering Experiment Station conducted an extensive investigation of the rupture of the drum, and authority was granted for a representative of the manufacturer to be present during the tests. The conclusions of this investigation were that no experimental or other evidence indicated that the failure of the *Aylwin's* boiler was due to the use of boiler compound containing sodium carbonate or sodium hydrate.

It is needless to say that any condition of design or construction that causes leaky seams which can be made tight only by excessive caulking might possibly produce brittleness in the metal of the plate.

The White-Forster boiler installed in the *Aylwin* class has D-shaped water drums, similar to the Yarrow type. In practice, it was found impossible to keep the seams of the White-Forster boiler tight, owing to the tendency of the drum to assume a circular shape under pressure. The manufacturers of this boiler have since corrected this by placing struts in these drums across the long diameter. It is also understood that similar trouble has not been experienced with Yarrow boilers.

With reference to the *Unalga* as another vessel having had trouble of a similar nature, not enough is known at the present time upon which to venture a statement as to the cause of failure. It is known, however, that the cracks in the steam drum plates of these boilers are similar to those observed in the *Aylwin's* lower drum plates; that the manufacturer of the boiler has conducted tests of the material, and that at the suggestion of the company the Naval Engineering Experiment Station will soon begin an independent examination and investigation of the material with a view to determining the cause of the peculiar conditions existing. It has also been learned that boiler compound in considerable quantity was used in this boiler, and that another vessel with a duplicate boiler, but in which only small quantities of the compound were used, has not had trouble.

APPENDIX

SYNOPSIS OF INVESTIGATIONS BY FRANK LYON, LIEUTENANT-COMMANDER U. S. NAVY[1]

From July, 1896, to August, 1899, Commander Lyon was Assistant Engineer, *U. S. S. Oregon*, and for the greater part of the time was in direct charge of her boilers. The feed water was kept in practically an open tank and was kept so strongly alkaline as to render it unfit for ordinary purposes. In this vessel corrosion of boilers was almost unknown.

From May, 1906, to May, 1909, Mr. Lyon was Senior Engineer Officer of the *U. S. S. New Jersey*. Troubles from corrosion were experienced throughout the three years. The corrosion was most noticeable in the piping in which the water was heated more or less between its entrance to and exit from the system.

The *Oregon* had fire tubular boilers and the *New Jersey* Babcock and Wilcox boilers. The water in the latter was kept slightly alkaline, but owing to fear of priming in these small drum boilers, it was never kept as alkaline as that in the *Oregon's* boilers. It was felt that every effort to prevent corrosion and to keep the boilers clean had been made, yet destructive local corrosion was going on and increasing in effect in spite of the zincs, non-acidity of the water, cleaning and other efforts to stop it. The Navy regulations had been followed, and experiments made, yet Mr. Lyon had failed in every particular to stop corrosion of metals having their surfaces in contact with water, and he was detached from that duty and left, knowing that there was something woefully wrong in the methods he had pursued and with the general methods of treating corrosion on shipboard.

With this excellent grounding in a knowledge of the effects of corrosion, he began at the Naval Engineering Experiment Station an experimental investigation of the problem of preventing corrosion. Tests were made in distilled, sea and brackish waters, in diluted sea and brackish waters with jars open and closed; in steel pots, glass jars and in a boiler. Very soon after starting this investigation it was seen that in the untreated distilled or in fresh waters the specimens of steel corroded all over; that as the concentrations[2] increased, the rate of corrosion at first decreased slightly and then began to increase. In the concentration where the rate showed an increase there were always evidences of local corrosion or pitting, and as the concentrations increased the rate of loss increased to a maximum, then fell rapidly to zero and remained there, the areas of local corrosion becoming smaller and more pronounced until they disappeared altogether in the concentration in which the loss was zero.

The concentration whose strength is just below the one in which local corrosion or pitting first appears, he called the lower-limit concentration; the one in which the rate of corrosion is a maximum, the critical; and the one just above the one in which the last signs of corrosion appear the upper-limit one for the metal tested.

In general the fundamental fact was established that if the

[1] The Journal of the American Society of Naval Engineers, August, 1912. Navy Department, Washington, D. C. Price $1.30 postpaid. Reprints of this article are also available. Many of the paragraphs above which refer to Mr. Lyon's work are abstracted liberally from his article.

[2] In this discussion, the concentrations mentioned are the alkaline salts in the water expressed in percentages of "normal solution." Equal volumes of normal solutions will just satisfy a chemical reaction completely without any surplus of reagents remaining on either side of the equation.

solution is kept sufficiently concentrated with sodium carbonate, corrosion is inhibited. That is the sum and substance of it.

Also, that the order of magnitude in which corrosion occurs in distilled-water solutions in the normal concentration of sodium nitrate, chloride and sulphate was in about the order of the strength of the acid radicals.

The upper and lower limit concentrations in those solutions in which they are found, vary with the metals immersed, and with the conditions of the surface of the metal in contact with the solution, both with regard to impurities in it and to the physical treatment it has received.

The last two points are very important to remember as accounting for local corrosions; and also this vital point:

That the rate of loss in the critical concentration is greater than that in the untreated water. In other words, it is better not to treat the water at all than to treat it near the critical values, and this can be done very readily by pouring compound into a boiler without paying attention to what the concentration is in the boiler, a fact that demonstrates the necessity for the individual testing of the water in the individual boiler under steaming conditions.

The limit and critical concentrations of the following solutions for one grade of steel were determined very carefully. Expressed in percentages of normal strength in distilled water, they are:

Solution	Upper limit	Critical	Lower limit
Sodium carbonate (calcined)	2.6	0.8	0.16
Caustic soda	2.6	0.8	0.16
Lime	2.6	0.6	0.15

These are the three salts used extensively in boiler treatment. They have practically the same characteristics as regards solution pressure, which is the measure of the tendency to corrosion.

Further work along these lines with open jars showed that the concentration of lime solutions weakened very rapidly, while those in caustic soda, sodium carbonate, disodium phosphate and the chromates maintained or increased their concentration as the water evaporated. Solutions of lime water exposed to the air may be non-corrosive to steel one day and corrosive the next, due to the absorption of carbonic acid from the air, while if the upper-limit concentration of sodium carbonate is made, steel thrown in it will not corrode until the concentration is brought below the upper limit by some external means.

The English of that is, use sodium carbonate if possible; do not use lime unless forced to, and when lime is used be careful not to work near the critical value.

Commander Lyon found that steel connected to copper by a good metallic conductor does not corrode in an upper-limit concentration of sodium carbonate, lime, caustic soda or disodium phosphate. In similar concentrations air, oxygen, carbonic acid gas, graphite, zinc oxide, mill scale, and other supposed exciters of corrosion have no effect upon steel or iron until the concentration is reduced below the upper limit for that steel. Steel was suspended in a glass basin in, and above, the limit concentration of sodium carbonate, and pure oxygen was blown under it in such a way that sixty bubbles a minute impinged on the steel and passed up along its sides; this continued for eight days, and no signs of corrosion were evident, and there were no losses of weight. This was continued for fifteen days longer, using air instead of oxygen, with the same result.

Zinc, being of higher potential than iron, will corrode in an upper-limit concentration for iron or steel.

It was found that the upper-limit concentrations for all irons and steels was about 2.6 per cent normal alkaline strength of sodium carbonate and of caustic soda solutions, in distilled and in sea-water. The highest concentration of any of these chemicals in which corrosion was found is 2.5 per cent of normal.

With pure feed water, sodium carbonate and trisodium phosphate, properly proportioned, will stop corrosion and priming if enough of the mixture is used. If impure water is used, then sodium carbonate, trisodium phosphate and cutch (containing tannic acid), when used in the right amounts, will stop corrosion, prevent priming, and also prevent scale from forming unless the saturation of sludge gets too high. Such a mixture is the Navy Standard Boiler Compound; and if by the use of this compound, the water in the boiler is always kept at a concentration of or above 3 per cent normal alkaline strength, no corrosion will take place, no scale will form and the water will be no more likely to prime than it would be if it were untreated.

The ingredients of the Navy compound are intimately united by thorough digestion, dried, finely powdered, and well mixed. They are readily soluble in water. The compound must show on analysis at least 76 per cent of anhydrous sodium carbonate (Na_2CO_3), 10 per cent of trisodium phosphate ($Na_3PO_4 \cdot 12H_2O$), 1 per cent of dextrine or starch, and sufficient cutch to yield at least 2 per cent of tannic acid, the remainder to consist of water and only such impurities as are common to the ingredients.

These investigations demonstrated why the boilers of the *Oregon* showed no signs of corrosion in three years, and why those of the *New Jersey* were considerably corroded in the same time. In the one the corrosion had been prevented by keeping the water strictly alkaline; in the other it had been materially aided by an insufficient degree of alkalinity. Mr. Lyon's conclusions are tersely expressed as follows:

"The writer has no hesitancy in saying that any boiler using any water can be kept free from corroding for any length of time if treated with soda, and if its concentration is maintained at or above 3 per cent normal alkaline strength. If the water is not to be kept sufficiently alkaline, it had better be kept neutral."—A statement that is absolutely borne out by the results of his treatment as applied at the Fruitvale power plant according to his method.

DISCUSSION

WALTER M. MCFARLAND. It is unpleasant to have to say that a number of the statements in this paper (as relating to marine boilers) are entirely inaccurate.

It is stated that the White-Forster boilers were of such design that it was impossible to keep the joints tight ordinarily. That statement is incorrect. The company with which I am connected has built all the White-Forster boilers constructed in this country, and I know of a large number used in the British Navy; and the boilers have given satisfaction generally.

A great deal might be said about this whole soda question, which is a very complicated one. I do not propose to go into it at length now, but some facts should be brought out. The *Unalga* was mentioned as having had boiler troubles, and it was said it was not known whether the trouble was due to soda or not, although it was mentioned there was some difference between the conditions on this vessel and a similar vessel.

The facts are that two vessels, the *Unalga* and the *Miami*, were built. They were sister ships, with identical boilers, and everything else,—and were put into commission at the same time. After the boilers of the *Unalga* gave trouble, the details of which I will not go into now, the suggestion was made to look into this soda question. It was found that in the preceding period of about eighteen months, since the boat had been commissioned, the *Unalga* had used 3,300 lb. of soda in her boilers, and the *Miami* had used only 300 lb. and had never had any trouble. The officials of the Coast Guard decided that it was undoubtedly soda which caused the trouble. They rescinded at once the order requiring soda to be used so that the strength of the solution should not be less than 3 per cent of a normal alkaline solution; and they ordered the present practice, which makes the water slightly alkaline, so that it is only a little more than neutral,—one-half of 1 per cent. of a normal solution.

The drum plates of the *Unalga* were badly cracked and the drums were condemned by the Coast Guard officials, removed,

and replaced by new ones. Very shortly after that, this matter was called to the attention of the Navy Department; and after the Navy officials looked into the story of the *Unalga* and what had happened, they also rescinded the order that not less than a 3 per cent of normal solution should be used. Since then they have been using one-half of 1 per cent solution.

There is another point in the paper to which I object. (I understand, of course, that the author and his associates got their information as best they could, but it is unfortunate that these erroneous statements should be made.) The statement is made, in the case of the *Aylwin*, that an investigation was made by the Naval Experiment Station at Annapolis, at which the manufacturer was permitted to have a representative present; and it was settled that the trouble with her boiler was not in any way due to soda.

As a matter of fact, there was a preliminary report from the physicist of the Experiment Station, but the matter is still under investigation at the Experiment Station and has not yet been settled. There is a great deal to be said about the matter; it is very complicated, and requires the most careful study and investigation. The reason for this is not because there is any doubt in the minds of those who have studied the subject, but the deleterious action of soda comes as such a surprise to those who encounter it for the first time that they want to investigate it carefully before endorsing this explanation of the phenomena.

I am authorized to say that later on, at the proper time, men who have made a very exhaustive study of this whole effect of soda solutions on boiler seams will prepare a paper, probably for this Society, which will give the latest possible information on the subject.

GEO. H. GIBSON said that he believed that the return to treating feed water inside the boiler, as advocated in this paper, is a step backwards, at least for stationary plants. That corrosion will not occur in a solution of proper alkalinity was originally demonstrated, he believed, by the German investigators Heyn and Bauer. Where water is treated externally to boilers, a greater or smaller excess of reagent is employed, which accumulates in the boilers, and the concentration of alkalinity can be controlled by periodic blowing down. If the water is treated cold, however, a considerable amount of scale and sludge forming solids fail to be eliminated in the softening system, as pointed out in the paper. On the other hand, if the water is treated above 170 or 180 deg. fahr., the reactions are practically instantaneous and the precipitate formed is coarse and settles rapidly. It is certainly better to remove these solids before the water enters the boilers, as practised in modern hot process softening systems, wherein the water is first heated and de-aerated by spraying through a steam bath before the chemical reagents are added. The proportions of the chemical should be based on an analysis of the water, and lime, as well as soda, is necessary for the correct treatment of many waters. In this way practically all of the scale or sludge-forming substances can be eliminated, as will be seen from the following analyses of water before and after treatment, as obtained in large steam plants.

	GRAINS PER U. S. GALLON	
	Before Softening	After Softening
Total dissolved solids	21.49	18.25
Total incrusting solids	18.28	1.35
Total dissolved solids	19.44	21.01
Total incrusting solids	9.04	0.32

The first analysis quoted shows that the water before treatment contained over eighteen grains per gallon of incrusting solids. After treatment it contained 1.35 grains and the excess of reagent used is 0.88 grain of sodium carbonate and 1.22 grains of sodium hydrate. The second sample was a water which not only deposited scale but caused corrosion, the corrosion being due to the presence of free sulphuric acid. Before treatment, this water contained 9 grains of incrusting solids and after treatment 0.32 grain. The excess of treating reagent used was 3.18 grains of sodium carbonate and 0.33 grain of sodium hydrate. He could give further examples, but these illustrate the point at issue.

This elimination of scale and sludge forming solids is found more important in preventing foaming and priming than is the keeping down of alkalinity in the boiler, as pointed out in the paper. As a matter of fact, boilers can be operated successfully at heavy overloads with high alkalinity, but not with high alkalinity combined with a large amount of sludge in the water.

A good example is presented by analyses obtained at one of the boiler plants of the U. S. Navy Department. Before the water softening system was installed at this plant, a great deal of trouble was experienced, but whether the Navy compound was tried or not he did not know. The total incrusting solids in this water were 23.29 grains. It was impossible to operate the boilers up to rating; there was severe priming, and it was found necessary to shut down part of the plant and turn off a number of lights and use less steam in order to carry the balance of the plant. It was the practice to wash the boilers out every 24 hours. After the water softening system was put in, treating the water hot, the incrusting solids were reduced to 1.75 grains, and the boilers operated successfully, although there was present in the water 67.63 grains of soluble salts.

The elimination of sludge is also desirable, because of the fact that sludge is carried over by even slight priming, and its accumulation may cause burning of superheating surface, lubrication troubles, and filling up of turbine blades. Such removal is doubtful where the precipitation of solids is brought about in the boiler itself, as advocated in this paper.

M. F. NEWMAN (written). The author's comparison of the difference in operating conditions between the use of hard, corroding feed water, and when subjecting the feed water to treatment with compound within the boilers is merely an illustration of changing the lime and magnesia salts into precipitates of such a form that they do not adhere to the surfaces within the boiler and the effect of introducing an alkali to combine with acid radicals that, under ordinary circumstances, would be free to attack the boiler metal.

The action of boiler compounds for the precipitation of lime and magnesia and the neutralizing of harmful acids has long been thoroughly understood, and it is well known that the addition of starch and tannin to a compound consisting principally of sodium salts tends to prevent the adherence of the precipitated lime and magnesia.

While the method described by the author may be considered novel, it is by no means rational, since to impurities already present in the boiler feed there is being added more impurities, so that the final effect is to increase the impurities in the water in the boiler without any compensation in the way of removing or freeing the water from suspended matter. The application of precipitants to water within the boiler is irrational and at the best is a mere makeshift. In the process of generating steam nothing but pure water is evapor-

ated so that there is a constant building up of impurities in the water remaining in the boiler. This applies to the soluble salts as well as the suspended matter.

When the reactions for the precipitation of lime and magnesia are carried on within the boiler, the result is to befoul the water with suspended matter and increase its density with soluble salts, so that more fuel is required for the generation of steam and a more frequent changing of the water to eliminate the soluble solids, as well as the suspended matter collected.

The logical method of overcoming scale and corrosion in steam boilers is to properly soften and purify the water by removing all permanent hardness, eliminating or neutralizing all acids, and reducing the remaining scale-forming substances to less than 3 grains per U. S. gallon, maintaining the alkalinity in the purified water between 3 and 4 deg. (1 deg. equivalent to 1 gr. calcium carbonate per U. S. gal.) with the effluent clear and free from suspended matter. Such a softened and purified water constantly supplied to boilers will not form scale or cause corrosion.

As an illustration of the results accomplished by this rational method with a properly designed apparatus, the following analyses of raw and softened water are submitted to show water from widely differing sources in close agreement as to alkalinity and softness.

ANALYSES OF RAW AND SOFTENED WATER

	A	B	C	D
	Grains per U. S. Gallon			
Volatile and Organic Matter	1.45	1.35	.75	.65
Silica	.65	.45	.35	.45
Iron and Alumina Oxides	trace	trace	trace	trace
Calcium Carbonate	17.75	1.75	10.50	1.50
Calcium Sulphate	3.06	....	....	....
Magnesium Carbonate	....	....	3.99	....
Magnesium Sulphate	12.42	....	5.07	....
Magnesium Chloride	....	....	.96	....
Magnesium Nitrate	....	....	.21	....
Magnesium Hydrate	....	.23	....	.52
Sodium Sulphate	25.77	43.59	....	6.18
Sodium Chloride	16.15	17.63	.13	1.32
Sodium Carbonate	....	.80	....	1.06
Sodium Hydrate	....	.68	....	.08
Sodium Nitrate	....	....	.21	.24
Total Solids	77.25	66.48	21.96	12.00
Suspended Matter	.15	trace	.15	trace
Free Carbonic Acid	.44	none	.44	none
Alkalinity	17.75	3.75	15.25	3.50
Incrusting Solids	33.88	2.43	21.08	2.47
Non-Incrusting Solids	41.92	62.70	.13	8.88

Analysis A Water from Shallow Creek Bank Well, Enderlin, N. D.
Analysis B Same water as A after softening.
Analysis C Spring water from Clarkdale, Ariz.
Analysis D Same water as C after softening.

HOWARD STILLMAN (written).—Concerning the use of the 3 per cent normal alkalinity and the Navy compound on locomotive boilers in main line service, I quite differ from Mr. Babcock as to results obtained on the locomotive boilers he has experimented with. In the first place Commander Lyon states distinctly that very rapid local pitting and corrosion occurs with alkaline solution under 2.6 per cent, placing the concentration of 3 per cent as the upper limit at which corrosion will positively stop. This concentration is equivalent to 92.7 gr. sodium carbonate per gallon, or 12.2 lb. per 1,000 gal., an amount of soluble matter locomotive boilers cannot carry without excessive foaming and priming. With the use of the Navy compound on locomotives Mr. Babcock is maintaining less than 1 per cent normal alkalinity, and there seems to be no reason to expect a decrease in corrosion under these circumstances, inasmuch as the potential of the liquid is considerably less than that of the metal with which it is in contact. The evidence brought out by Commander Lyon's paper indicated that corrosion would not stop until the potential of the liquid was in excess of the metal, and that 2.6 per cent normal alkalinity was required to produce this.

On many occasions I have inspected locomotive boilers using the Navy compound and as yet do not find any evidence of decrease in pitting and corrosion in bad water districts.

The Mallet Consolidation engine 4031 to which Mr. Babcock refers, was first placed in service with new firebox on Dec. 20, 1912. The Navy compound was first used in July, 1914, and maintained until June, 1915, when the engine was withdrawn from service and condemned for new firebox. During the interval the engine ran 19,790 miles. I made a thorough inspection of the firebox in the boiler shop after it had been removed, and found the crown sheet badly pitted and corroded on the water side. The Navy compound was used for a period covering but 43 per cent of the engine's mileage, but the extent of the pitting and corrosion appeared to exceed that shown by the firebox of an engine of the same class in like service on the same district, that had used Navy compound only 4 per cent of its mileage, practically none. The evidence from engine 4031 does not appear to bear out Mr. Babcock's statement regarding the effect of the compound in lengthening the life of the boiler. This engine was shopped, not for machinery, but for boiler repairs, with a firebox mileage of but 45,501.

Mr. Babcock states that the new water at Bakersfield is very light. The engineers in this district state that it appears to be light only when used with Navy compound. On engines not using Navy compound no trouble is experienced with "lightness" of this water.

Nothing new is here brought out regarding the specific action of carbonates or phosphates of soda, of which the Navy compound is composed chiefly, on such solids as produce permanent hardness. The compound is effective in breaking up and decreasing scale formation, throwing out such matter within the boiler as insoluble carbonates or phosphates in definite proportion.

The tendency for boiler water to foam and prime is a direct function of the rate of evaporation demanded. The evaporation of the Fruitvale boilers was shown by official test to be approximately 3.7 lb. equivalent per sq. ft. of heating surface per hour. My test records of the Mallet locomotive boilers show the corresponding equivalent to be at the rate of 7,937 lb., or an increase over the stationary practice of 114 per cent. There is a great deal of complaint from our mechanical department on the district over which the Navy compound has been used from foaming and priming.

Mr. Babcock makes reference to the use of trisodium phosphate as a specific against foaming. The evidence in operation of our power does not show this to be true. He states that trisodium phosphate prevents the rise of the surface tension of the solution and consequent priming. I do not find any verification of this statement in principle.

The Navy compound is being applied by Mr. Babcock most generally to superheater locomotives. Superheaters are placed in boilers at considerable expense, and if, owing to circumstances, their superheating surface is converted to evaporating surface, as with priming, their efficiency is impaired in direct proportion.

In order to determine the loss of superheat efficiency from this cause, tests were made with Mikado engine 3239 in passenger service between Los Angeles and San Luis Obispo, a run of 223 miles. This engine is one of our latest type Mikados, 26x28 in. cylinders, 210,400 lb. on drivers, and 63 in. wheel. It has used the Navy compound and trisodium phosphate since July, 1915. Full details of these tests are on file, and a summary of them is here given.

TABLE 1 EFFECT OF NAVY COMPOUND IN LOCOMOTIVE OPERATION

	Out Trip—L. A. to S. L. O.		In Trip—S. L. O. to L. A.		Totals and Averages	
Date	9-23-15	9-28-15	9-24-15	9-29-15		
Navy Comp. & Tri-Sod. Phos.	with	without	with	without	with	without
Gal. fuel oil per 1000 ton-miles	17.59	16.32	11.26	10.78	13.55	12.74
Average superheat, deg. fahr.	191	265	242	249	221	254
Per cent more fuel per 1000 ton-miles	7.78	....	4.45	....	6.35	....
Per cent less superheat	27.92	....	2.81	....	12.99	....

The excesses shown for the outward trip are due to the treatment with 5 lb. Navy compound and 9 lb. trisodium phosphate, given at Los Angeles. With no treatment at San Luis Obispo on return trip the losses were less.

Regarding the instructions that engineers operating engines which are being treated with this compound should, as often as necessary, avail themselves of the opportunity to use the blow-off cock, heat losses from blowing off are directly proportional to the volume of water wasted and heat units therein at 200 lb. pressure.

F. F. VATER contributed a written discussion, in which he stated that the water used at Fruitvale is not a bad water; as far as the analysis shows, the only corrosive elements are nitrate of lime and chloride of magnesium. In any properly operated treating plant, these two substances would have been changed to sodium chloride and sodium nitrate, both of which are inert. The analysis says nothing of the dissolved oxygen, which may or may not have been present; if present, it would have a material bearing on the trouble.

If there were no dissolved oxygen in the water after passing through the softening plant, absolutely nothing of a corrosive nature remained in the water after treatment. This being true beyond argument, he suggested that the cause of the pitting and corrosion lay entirely outside the quality of the water, and that an intelligent search would have developed the cause.

J. H. Andrew has definitely shown that a saturated solution of caustic soda will embrittle iron and steel plates by occlusion of hydrogen. At boiler temperatures it is well known that soda ash yields up its carbonic acid, changing to caustic soda. We have, therefore, in the boiler caustic soda in a dilute solution, knowing that caustic soda in saturated solution crystalizes steel and iron.

A score of plants use in their boilers well water containing sodium carbonate, and have had trouble with cracked plates, tears, ruptures and boiler explosions. It cannot be proven that soda ash was the cause, because a wide gap exists between a saturated solution, such as used by Mr. Andrew, and a dilute solution, which is all that could exist in the boiler. We know that in saturated solution the crystallization of the metal takes place in short periods of time, numbered by days. We know further that several years' time elapsed between the introduction of the water containing sodium carbonate and the culmination of the trouble.

It stands to reason that a dilute solution will bring about the same effect, given sufficient time, that a saturated solution will bring about in a short time. In none of the cases where trouble came, due to crystallized plates, did the alkalinity of the water entering the boiler equal 1/200 part normal. What then will occur in time to a boiler in which 3 per cent normal alkalinity is maintained?

He did not like the density of the water where Navy compound is used. Neglecting the starch, trisodium phosphate or tannic acid at Fruitvale, we have a saturation of 998.667 grains per gallon, corresponding to a density of 1.017. Sea water has densities ranging from 1.026 to 1.03. He had seen tube after tube burned out in cases where the water had a density of 1.0032. Rather than take any chances beyond 1.0032, he would use barium hydrate to precipitate the sulphate, and get rid of the sodium sulphate end product.

Mr. Babcock speaks of loss of tubes since the adoption of the Navy compound, from other causes than pitting and corrosion. To him, the cause is excessive density of the water evaporated, and the wonder is that the tube loss from density is not greater than the tube loss from pitting and corrosion.

The whole tendency of the times in boiler practice is to obtain pure waters. With pure water high evaporative capacities can be obtained without trouble, and this cannot be done by using Navy compound. With boilers constructed of pure metal, waters treated hot, and low excess of soda ash, much more economical boiler performance will be obtained, and no pitting or corrosion due to auto-electrolysis or anything else will occur.

L. M. BOOTH[1] (written). It is surprising that Mr. Babcock should have been content to follow, without modification, the error of Mr. Lyon of feeding to boilers a substance like carbonate of soda which contains over 41 per cent carbon dioxide, —itself a fruitful cause of corrosion. It is safe to assume that, by the use of such a large quantity of soda ash in boilers, he has transferred some of his corrosion troubles to steam lines and other surfaces beyond the boilers.

The record of the reduction of corrosion is important, although the author would have had greater success by a judicious use of caustic soda instead of sodium carbonate. It is a fact that sodium carbonate changes to caustic soda in the boiler, so why add the corrosive carbon dioxide which must necessarily be promptly expelled with the steam to get in its corrosive work elsewhere? Besides, the water in question is one which requires a caustic treatment instead of a carbonate treatment.

All of the chemical information available on boiler water treatment is none too much to command when tackling a corrosion problem, so it seems that the author's "one corrective to all waters" is an endeavor to make the task more easy and simple than it really is. In the first place, let it be understood that by the elimination of the lime process—assuming that it was efficiently carried out—there was fed to the boilers of this power plant, every day of service on the rating basis, 668 lb. of sludge which might just as well have been diverted to the sewer. The presence of this suspended matter, 1 lb. per 1000 gal. of water evaporated, increases the tendency of foaming and necessitates more blowing off than if Mr. Babcock had used the lime process on the feed water as preliminary to the excess soda method in the boilers.

While no data are given to show the quality of the water delivered by the water treatment plant which was abandoned for the Navy compound process, it is to be assumed that the water was not properly treated, since in Mr. Geibel's supplement are recorded unfavorable results in transformer cooling coils, etc., and also that there was hard scale in the boilers.

I wish to endorse the general plan of testing the boiler blow-off water, although I recommend tests be made to determine the amount of suspended matter, in addition to the alka-

[1] President, L. M. Booth Co., Hudson and Morris Sts., Jersey City, N. J.

linity tests described. The additional information is valuable and it is but slight trouble to obtain it, the process being much quicker and simpler than the alkalinity test.

WILLIAM KENT said it seems the author has established his point in regard to the particular water dealt with, but the paper contains no reference to water treatment in general.

He thought several terms in the paper should be made clearer, for instance, "3 per cent normal," "back shopping," "engine left in chain gang," "light water," etc.

Regarding the composition of the Navy compound, he thought the expression "sufficient cutch to yield at least 2 per cent tannic acid" should be translated so that engineers could go to the chemical manufacturer and buy the materials for making the compound.

E. N. TRUMP thought the paper implies that the cracking is due to excess of caustic soda, whereas it has not been proven that caustic soda is the cause of the cracking of steel. It may be the cause of cracking of some kinds of steel, but not enough is known about the subject to make exact determinations. He had undertaken many investigations and performed various kinds of experiments to find out the cause of the cracking of steel in contact with caustic soda, but so far without result.

He thought the statements made in the paper in this connection are not based on adequate scientific investigation. From his experience there certainly existed no cracking because of carbonate of soda. An excess of caustic soda appears in some instances to give trouble, but only in the case of certain kinds of steel.

FREDERICK E. GEIBEL said, in reply to a question by E. P. Bates, it was found in experiments that corrosion was most rapid with a temperature of 190 deg. fahr., and results with the boilers in service checked with experimental figures.

J. F. WALSH explained the shop terms questioned by Professor Kent. He said "back shopping" refers to putting a locomotive in what is termed the "back shop" after it is practically worn out. In this shop the flues are ordinarily removed, and the entire engine, boiler and parts thoroughly overhauled.

The term "chain gang" is used in the practice of running engines with other than regularly assigned crews, where the crews vary from trip to trip. A chain gang is such a crew.

"Light water" is water which foams easily. Such water is likely to be carried over into the cylinders and cause much trouble.

THE AUTHOR. In answer to those advocating pre-treating of the boiler water, I might say that any method of purifying the water before it enters the boiler is certainly preferable, all things considered. The hot treatment is believed to be more effective than the cold, but is necessarily not applicable to water for locomotives. The cold treatment has been used very extensively, but unless water is given ample time to settle, the desired results are not obtained. Recent experience with lime-treated water by the cold process bears out the statement made by Commander Lyon—that lime water under certain conditions is highly corrosive.

Mr. McFarland promises some further data on the destructive action on boilers carrying water at high alkalinities. Since our experience has failed to develop a single case of trouble from this source, his paper will be received with much interest. It is to be hoped that he will be sufficiently explicit, and that his statements will be sufficiently supported by unbiased evidence to justify his charges that many of my statements are inaccurate.

It is quite evident that Mr. Stillman has not followed personally the tests on locomotive boilers using Navy compound. No attempt has been made to carry a 3 per cent solution in locomotive boilers, but only a sufficient quantity to prevent scale and corrosion. The mileage on Engine 4031 given by Mr. Stillman may not be considered as a very good record, but it is 59 per cent greater than the previous record of this same engine not using the compound. His statements in regard to the effect of the compound on the superheat are based only on one round trip. Fuel records on eleven superheat engines over a period of twenty months show a 5 per cent decrease in gallons of fuel per 1000 ton-miles in favor of the engines treated with Navy compound. And he persists in a total lack of appreciation of the well-known fact that a boiler can better be blown off by a series of quick, short blasts than by opening the cock wide for several minutes. Furthermore, he fails apparently to comprehend the meaning of the upper and the lower limits fixed by Lyon's investigation, beyond which *in both directions* corrosion does not occur. The zones between neutrality and the lower limit, and between the upper limit and any higher degree of alkalinity yet observed, are those of no corrosion. (See "Effect of varying degree of concentration of alkaline solutions," in paper by Lieut.-Com. Frank Lyon.[1])

The remainder of Mr. Stillman's discussion is founded on evidence derived from sources we have long since found to be unreliable.

In a paper before the American Waterworks Association at its Urbana meeting in 1915, W. A. Pownall covered the subject of soda ash treatment of water for locomotive use in a comprehensive manner. The paper stated:

"The prevention of scale formation may be accomplished by using water softeners which remove practically all of the hardness and suspended solids, or by treating each supply of water with enough soda ash to neutralize the sulphate hardness and provide a slight excess (of soda ash), all of the scale forming solids being converted into a soft sludge which can be readily blown out through a properly located blow-off cock. Soda ash or sodium carbonate is found in some waters, and unless it is so high as to cause foaming trouble, waters of this type are desirable for boiler purposes in that they will not form scale and require no treatment. The Wabash Railroad has sodium carbonate waters at Mansfield, Bement, Sidney and Stonington, Ill., and would like to find more supplies like them, but unfortunately most waters contain sulphate hardness and must be treated.

The soda ash is changed to sodium sulphate in the boiler, and locomotive boilers worked to full capacity and using surface waters will usually be in a foaming condition when this sodium sulphate (and other sodium salts) in water from the boiler are over 2000 parts per million. Where only clear well waters are used, this limit will be 2500, or even higher, and in stationary boilers, with their lower rate of evaporation and greater steam space, the foaming point may be 5000 to 6000 parts per million. The mud and carbonates precipitated in the boiler may cause trouble in three ways:

1 The foaming tendency of the water in the boiler increases.
2 Heavier scale will form at times when treatment is light.
3 There is danger in mud-burning.

It is essential, therefore, that engines using soda ash treated water be equipped with suitable blow-off arrangements for removing the sludge from the boiler."

[1]Jour Am. Soc. Nav. Engrs., August, 1912.

CAPACITY AND ECONOMY OF MULTIPLE EVAPORATORS

BY E. W. KERR, BATON ROUGE, LA.

Member of the Society

DURING the last few years, the author has carried on a large number of investigations of both the capacity and economy of multiple evaporators and vacuum pans. This work has been done in the laboratory on a small apparatus, and in sugar factories on apparatus of commercial size and under regular operating conditions. The results of much of the laboratory work were given in a former paper before this Society,[1] and the object of the present paper is to give results of experiments made since the first paper was written, together with certain general observations.

The process of evaporating in sugar factory work consists of two distinct parts: *First*, the juice with a density of 12 deg. to 18 deg. Brix[2] is concentrated by evaporating off part of its water to approximately 55 deg. Brix in a multiple evaporator. *Second*, the syrup produced is then taken to a vacuum pan working single-effect, and where further water is removed by

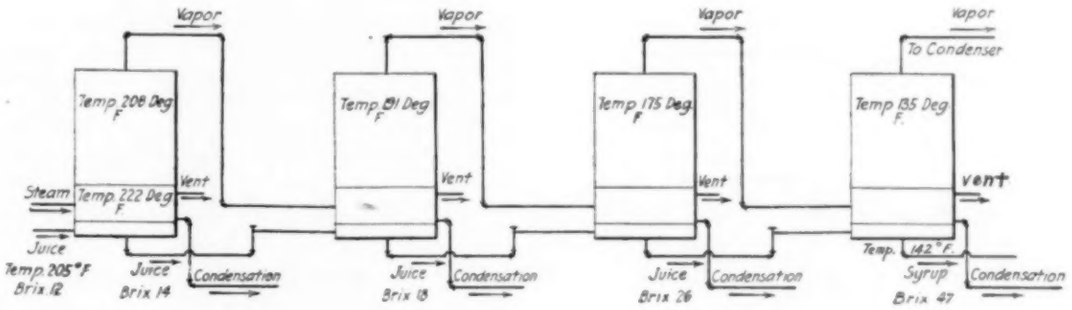

FIG. 1 QUADRUPLE EFFECT FOR SUGAR JUICES. TEMPERATURES AND DENSITIES OBTAINED FROM TEST

[1] Tests upon the Transmission of Heat in Vacuum Evaporators, Trans. Am.Soc.M.E., vol. 35, p. 731.

[2] The Brix saccharometer or hydrometer indicates directly the percentage of sugar dissolved.

SYNOPSIS OF PAPER

This paper discusses the capacity and economy of multiple evaporators used in the process of manufacture of cane sugar. The paper is the second paper presented to the Society by the author on this subject, the first given two years ago dealing with laboratory apparatus of the same type. The complete results of the author's tests on multiple effect evaporators under regular operating conditions, as embodied in the second paper, are given herewith, together with an adequate summary of the balance of this paper.

In the tests of capacity and economy recorded, a typical log included observations of the pressure of vacuum in the steam or vapor space of each body; temperature and density of juice entering and leaving; weight of juice entering or leaving; weight of condensed steam from the first body, etc. The evaporators tested included double, triple and quadruple effects of the vertical submerged tube, the horizontal steam tube, the horizontal film, and the vertical film types, also the first of these with special steam distribution and running under vacuum, and again with atmospheric pressure in the last body, and lastly vertical steam tube evaporators with special means for venting each tube. Various methods of removing condensation and of venting the incondensable gases were employed, and the tests were made under several conditions of heating surface.

The types of evaporators tested were: A, vertical submerged tube (so-called standard); B, horizontal steam tube; C, horizontal film; D, vertical film; E, standard type with special baffle and under vacuum; F, same as E but no vacuum; and G, vertical steam tubes with special means for venting each tube.

All the types tested are illustrated in the paper, and results of all tests are given in tables and curves. Table 1 summarizes the principal data from the tests, and Table 5 gives all the data relative to economy.

The tests showed a great variation in the coefficient of heat transmission, not only for different types, but in different evaporators of a given type. This variation was due to difference of design and operation, including steam velocity and density, method of venting, cleanliness of heating surface on both steam and juice sides, velocity of liquor circulation, density and purity of liquor and height of boiling.

The coefficients of heat transmission in the factory evaporators were, as a rule, lower than those obtained with the laboratory apparatus, previously recorded, and higher than is usually obtained with surface condensers. The average coefficients obtained in the tests of different types were as follows, the coefficient for type A being taken as 100:

A	100
B	108
C	199
D	135
E	126
F	255
G	149

These, however, cannot be taken as an absolute measure of the heat transmitting capacity per unit of heating surface in the different types, because conditions were not equally favorable in all cases.

In thirteen of the tests, the steam condensed in the first body was determined, and from this and other data, the thermal efficiency was calculated. The thermal efficiency varied from 85 to 97.5 per cent, the variation being due to difference in the radiation losses and vent losses. The radiation loss varied with the capacity of the evaporators, the number of bodies, the proportion of external surfaces covered and the difference between the temperature of the steam inside and the atmosphere outside.

The discussion which follows the paper gives considerable information on sugar evaporation, with special reference to heat transmission in multiple evaporators. In one discussion the author's results are compared with those by other investigators. Other subjects of discussion are loss of sugar due to entrainment, effect of juice scale and viscosity, etc. To all the points raised the author replies in his closure.

Presented at the Spring Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New Orleans, La., April, 1916. Pamphlet copies without discussion may be obtained; price 15 cents to members, 30 cents to non-members.

evaporation under conditions suitable for crystallizing the sugar, the final density being in the neighborhood of 95 deg. Brix.

This paper will consider the first part of the process, namely, the evaporation in multiple effect. Fig. 1 shows diagrammatically the general arrangement of a quadruple effect. Steam is admitted to the first body and is condensed, and the latent heat is transmitted in succession through the heating surface of the four bodies, the boiling temperature in each body being lower than in the preceding body.

The thin juice enters the first body, where a portion of the water is removed. The juice then passes in succession to the other bodies, in each of which a portion of the water is evaporated, and leaves the last body at a density which is hand-regulated by means of valves in the liquor lines entering the different bodies. The juice entering each body, except the first, is hotter than the boiling temperature in that body, consequently some heat is delivered by the liquid as well as the steam. Whether heat enters the first body in the liquid or not depends upon the temperature of the entering juice.

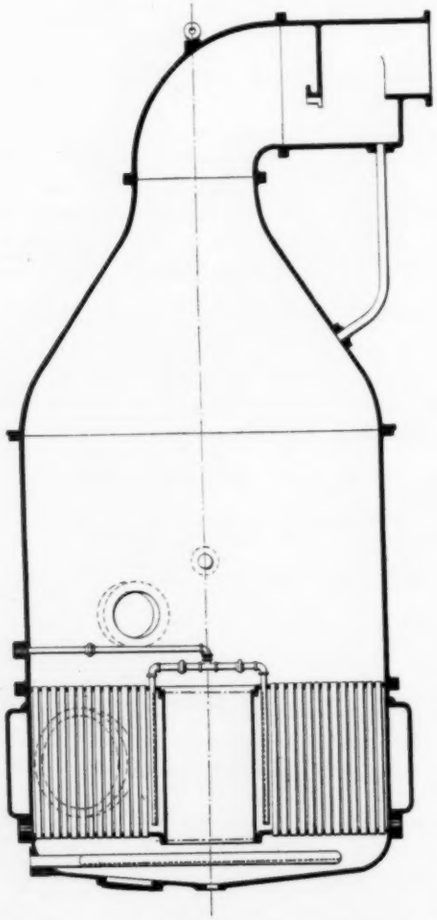

FIG. 2 ONE BODY OF VERTICAL SUBMERGED TUBE EVAPORATOR WITH BELT STEAM DISTRIBUTION. (TYPE A)

CAPACITY

The capacity of evaporators depends on two general factors: *coefficient of heat transmission* and *temperature fall.*

The factors affecting the coefficient of heat transmission, discussed in the first paper,[1] may be enumerated as

1 *a* Steam distribution; *b* Steam velocity
2 Density of heating steam
3 Quality of heating steam (whether superheated or not)

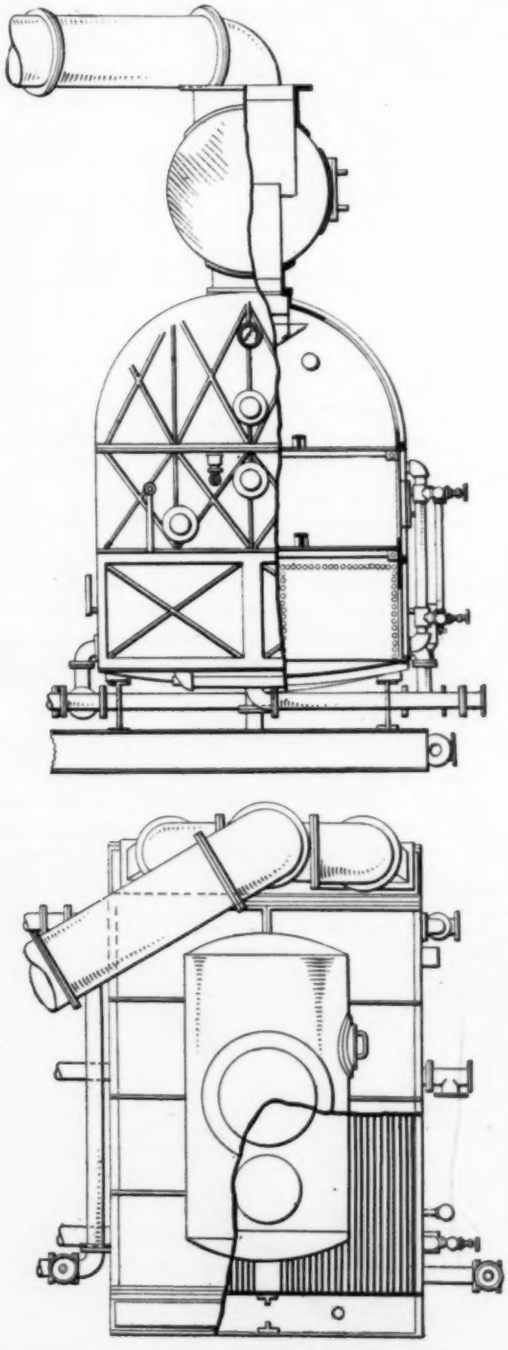

FIG. 3 HORIZONTAL EVAPORATOR (TYPE B)

4 Presence of air or other incondensable gases in the steam, which may be expressed mathematically by the ratio $P_a \div P_t$
5 Presence of condensation on the heating surface

[1] Tests upon the Transmission of Heat in Vacuum Evaporators, Trans. Am.Soc.M.E., vol. 35, p. 731.

6 Cleanliness of heating surface (steam side)
7 Material, thickness and molecular structure of tubes
8 Cleanliness of heating surface (liquid side)
9 Velocity of liquor circulation

The temperature fall depends on the following factors:

10 Pressure of steam supplied to first body
11 Vacuum in last body
12 Hydrostatic head (height of boiling)
13 Presence of air or other incondensable gases in the steam (see item 4 above)
14 Density of liquid being boiled
15 Purity of liquid being boiled.

The heat transmitted from steam through a metal wall to a liquid being boiled takes place in three steps: *a* From the steam to the initial surface of the metal; *b* From the initial surface through the metal wall to the cooler surface; *c* From the cooler surface to the liquid being boiled. Items 1 to 6 affect *a;* item 7 affects *b;* items 8 and 9 affect *c*, and items 10 to 15 affect temperature fall.

The paper here considers the effect of design in the various types of evaporators upon these several factors.

TESTS OF EVAPORATORS IN SUGAR FACTORIES

The object of these tests was to gather data regarding the capacity and economy of different types under regular operating conditions. Observations were made of practically all

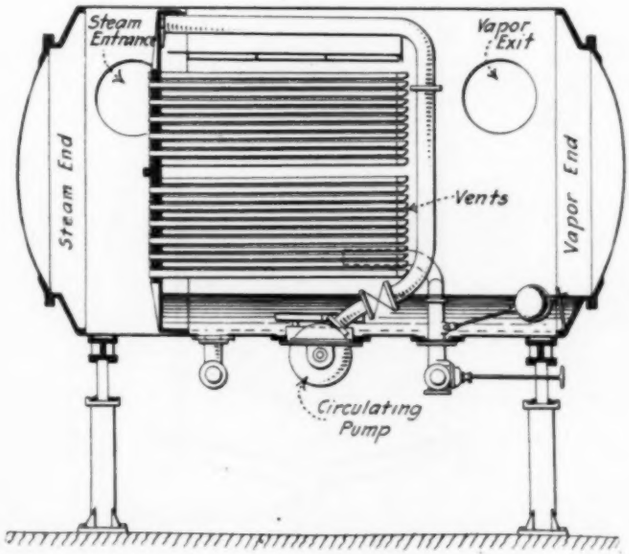

FIG. 4 ONE BODY OF TYPE C EVAPORATOR

factors which might affect the results. A typical log included observations of the pressure or vacuum in the steam or vapor space of each body; temperature and density of juice entering and leaving; weight of juice entering or leaving; weight of condensed steam from the first body, etc. This form of log was used in tests where data regarding both capacity and economy were sought. It was not possible to weigh the condensed steam from the first body in all cases, so that only capacity data were obtained in many of the tests. In the logs for such tests the weight of the condensed steam from the first body was omitted.

The weight of juice was determined by measuring the volume in factory tanks and then calculating the weight from the densities. The condensation from the first body (steam supplied) was determined by weighing or by a venturi meter, the former in most of the tests.

The instruments for measuring pressures, vacuums, temperatures, etc., were calibrated.

EVAPORATORS TESTED

The evaporators tested included double, triple and quadruple effects, also the following types:

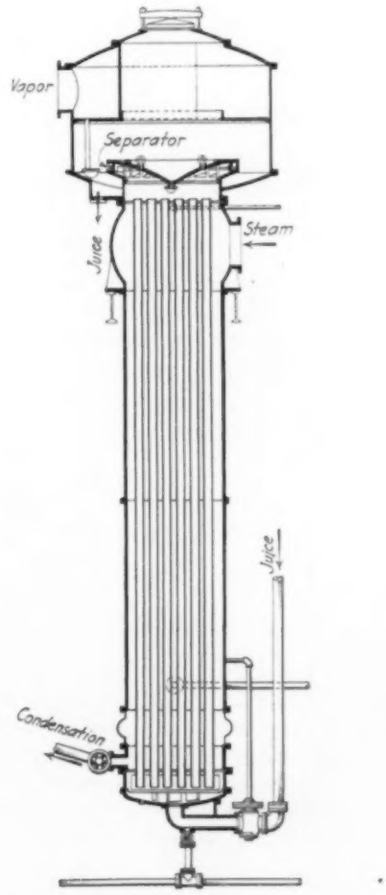

FIG. 5 ONE BODY OF TYPE D EVAPORATOR

A Vertical submerged tube (so-called Standard, Fig. 2).
B Horizontal steam tube (Fig. 3).
C Horizonal film (Fig. 4).
D Vertical film (Fig. 5).
E Standard type with special baffle steam distribution, running under vacuum (Fig. 6).
F Same as E but with atmospheric pressure in last body, no vacuum apparatus being used.
G Vertical steam tubes with special means for venting each tube (Double Tube, Fig. 7).

Types A and B are so familiar that it is not necessary to describe them. It may be well to state, however, that the majority of the sugar house evaporators used in practice belong to one or the other of these two general types.

In type C the horizontal tubes are expanded at one end

into a thick tube plate, and at the other are closed except for a small vent which releases the incondensable gases into the vapor space. The water of condensation leaves the tube at the end where the steam enters. Juice is supplied by centrifugal pumps to a distributor above the tubes and falls in a film from one tube to another. The piping is such that the juice may be recirculated over the tubes until the desired concentration in each body is obtained.

In the vertical film type D, the juice level is near the bottom of the tubes, the latter being approximately 20 ft. long. A rapid current of steam rising through the tubes sweeps juice

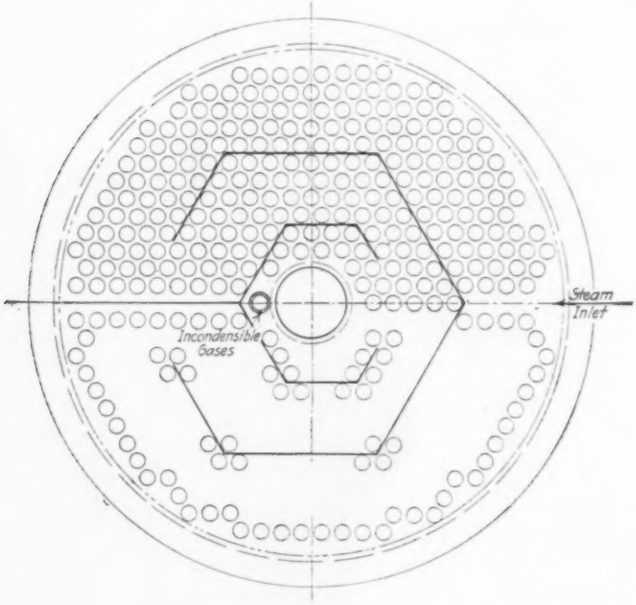

FIG. 6 STEAM DISTRIBUTION (TYPES E AND F EVAPORATORS)

along with it. The pressure of the steam on the interior of the tube keeps this juice as a film (often referred to as *climbing film*) on the tube surface. The juice thus projected upward, on issuing from the tops of the tubes, enters a special separator which separates it from the vapor. The juice and vapor then pass from body to body in the usual manner.

CONDITIONS OF OPERATION

In order to interpret the results of the tests, it is important to note some of the details of conditions of operation. The most important of these are:

1 Method of removing condensation
2 Method of venting the incondensable gases
3 Condition of the heating surface.

Referring to Fig. 1, the removal of condensation from the steam compartments may be effected by:

a Pumps from each body
b Siphoning the condensation from body to body, a pump being used to remove it from the last body
c Barometric leg pipe; this method can be used only in case the evaporator is high enough to give a column of water sufficient to balance the vacuum in the space being drained.

The venting of incondensable gases may be effected by:

a Small pipes tapped through the shell just under the top tube sheet
b Small pipes tapped into the top tube sheet and located near the downtake. Usually two or four of these tubes are used, which are connected together inside of the vapor space with a single pipe brought through the shell and a valve placed on the outside for control
c In horizontal evaporators, the steam chest opposite the steam entrance is vented
d Special methods depending on the type of evaporator.

In all of the above, the vented gases may be taken direct to the condenser or to the next body, though so far as heat transmission is concerned, it is doubtless better to vent direct to the condenser. Usually valves are placed in vent lines in order that control may be exercised. In some cases, the venting is continuous and in other cases intermittent, depending upon the ideas of the operator. In types C and G special means of

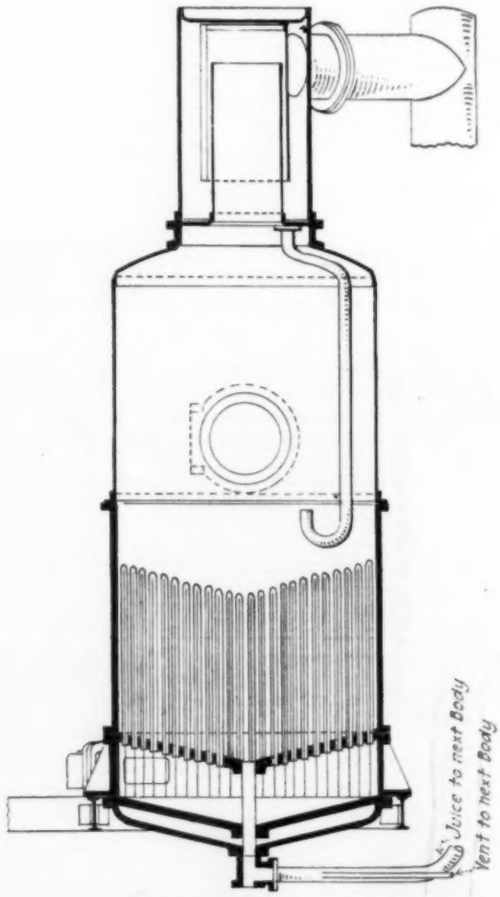

FIG. 7 DOUBLE TUBE EVAPORATOR (TYPE G)

See also Fig. 6, Tests upon the Transmission of Heat in Vacuum Evaporators, Trans. Am.Soc.M.E., vol. 35, p. 731.

venting are used which have been explained above. Data regarding the methods of venting are given in the tables:

RESULTS OF TESTS

Table 1 gives the more important data from the tests on multiple evaporators. Fig. 8 is a graphical log of a typical test.

The percentage evaporation by weight was calculated by means of the formula $X = \frac{(B-b)}{B} \times 100$, in which B is the Brix of the juice leaving, b, the Brix of the juice entering, X

the per cent water evaporated in terms of the weight of the juice. In determining the percentage evaporation by volume, the formula $X = 100 - 100\ (gb/GB)$ was used, g being the specific gravity of the juice entering, and G the specific gravity of the juice leaving. In most cases, the volume of the juice leaving was measured in factory tanks, the weight of juice entering and the weight of water evaporated being calculated by the use of the first formula above.

It is customary to make evaporator guarantees on a basis of 75 per cent evaporation by volume. As the initial and final densities of the juice are seldom such as to give exactly 75 per cent evaporation, it is necessary to determine the "equivalent volume of juice in gallons per 24 hr." by calculation. There seems to be no standard unit for rating evaporators. Sometimes an evaporator is guaranteed to handle a stated number of gallons of juice per 24 hr. with 75 per cent evaporation, nothing being stated as to the temperature of the juice; in other cases the temperature of the juice is specified. Probably the best standard rating would be "equivalent gallons of juice handled per 24 hr. with 75 per cent evaporation." Primarily a multiple evaporator is supposed to evaporate and not heat; actually, however, the juice may enter the first body at a temperature lower or higher than that of boiling.

The following example shows the method used in calcu-

TABLE 1 PRINCIPAL DATA FROM TESTS ON SUGAR HOUSE EVAPORATORS

No.	Duration, Hr.	Type	Number of Bodies	Rated Capacity, Gal. per 24 Hr., 75 Per Cent Evaporation	Length of Tubes, Ft.	Diam. of Tubes, In.	Heating Surface, Each Body, Sq. Ft.	Steam Pressure 1st Body, Lb. Abs.	Steam Pressure Last Body, In. Abs.	Temperature, Deg. Fahr.		Density Degrees Brix at 17.5° C.		Method of Removing Condensation*	Method of Venting*	Number of Days Since Cleaned	Per Cent Evaporation		Juice Treated per 24 Hr. Equiv. to 75 Per Cent Evap., Per Cent of Rated	Water Evaporated, Lb.	Water Evaporated per Lb. of Steam Supplied, Lb.	Water Evaporated per Sq. Ft. Heating Surface per Hr., Lb.	Thermal Efficiency, Per Cent
										Juice Entering	Juice Leaving	Juice Entering	Juice Leaving				By Weight	By Volume					
1	7.13	A	4	290,000	4.5	2	4504.8	16.3	1.8	183.5	101	13.7	50.2	*f*	*bc*	6	72.7	76.6	137	587,914	....	5.44	....
2	6.00	A	3	270,000	4	2	3740	14.6	3.6	185.9	134.2	15.2	55.5	....	.....	3	72.6	77	.....	350,584	....	5.19	....
3	6.66	A	3	290,000	4	2	3983	15.3	3.2	188.6	....	13.2	52.2	*e*	none	3	74.7	78.6	102	505,304	....	6.35	....
4	12.0	A	3	185,000	4	2	2579	15.6	3.4	198.4	....	15.4	61.1	*e*	*bd*	0	74.7	79.4	138	933,684	....	10.38	....
5	5.75	A	3	280,000	4	2	....	16.7	4.9	183.8	....	13.6	51	*e*	note 1	0	73.4	77.4	83	327,466	....	4.96	....
6	4.33	A	3	210,000	4	2	2855	14.7	3.5	194	124.5	13.3	58.2	*e*	none	7	77.2	81.3	87	195,763	....	5.27	....
7	4.92	A	2	125,000	4	2	1901	14.9	5.2	206.7	128.9	15.9	56	*e*	*ad*	....	71.6	76.1	145	104,775	2.09	5.67	....
8	3.5	A	2	120,000	4	2	1808	13.6	5.1	172.7	137.1	16.9	42.4	*e*	*ac*	12	60.3	64.4	86	88,255	....	6.95	....
9	6.0	A	2	130,000	4	2	2137.6	14.4	4.1	176.8	123.2	13.6	52.4	*e*	none	0	74.1	78.1	63	124,474	....	4.85	....
10	4.5	A	2	130,000	4	2	2137.6	14.5	3.8	174.3	123.1	13.2	51.3	*e*	none	6	74.3	78.2	42	54,504	....	3.19	....
11	6.0	A	2	100,000	4	2	1585.6	14.9	6.2	185.2	143.4	15	48.3	*e*	*bd*	3	68.9	73.01	64	95,857	....	5.04	....
12	6.16	A	2	100,000	4	2	1585.5	14.7	6.9	188.0	144	14.1	49.4	*e*	*bc*	0	71.5	75.5	90	141,888	....	7.26	....
13	5.0	A	2	125,000	4	2	2042	14.7	5.0	188.6	140	13.3	54.2	*e*	*bd*	3	75.4	79.4	151	239,478	....	11.72	....
14	4.0	B	4	145,000	9½	¾	2000	22.9	3.1	200	119.8	18.1	55.9	note 2	*d*	6	67.6	72.5	109	155,198	3.52	4.85	85.06
15	4.0	B	4	145,000	9½	¾	2000	21.4	3.8	199.7	129.2	17.5	62.9	note 2	*d*	3½	72.2	77.2	174	248,701	3.7	7.77	89.05
16	6.0	B	4	145,000	9½	¾	2000	23.4	4.0	200.5	127.3	16.0	47.2	note 2	*d*	7	66.1	70.3	107	225,586	....	4.69	....
17	6.0	B	4	250,000	13	⅞	3432	18.7	3.7	181.0	....	13.0	57.5	*e*	*c*	0	77.5	81.4	86	314,062	3.4	5.08	90.48
18	4.5	B	4	250,000	13	⅞	3432	17.4	5.0	196.5	140	13.0	59.3	*e*	*c*	0	78.1	82.1	116	319,833	....	5.18	....
19	6	B	3	125,000	11	¾	1560	15.5	7.5	186.2	155	13.2	54.3	*e*	*c*	....	75.7	79.7	62	113,716	2.86	4.05	100.4
20	5.33	B	3	200,000	13	1¼	2849	20.9	3.3	195	130	10.6	58.3	*e*	*c*	1	83.5	85.1	191	502,311	....	11.03	....
21	6.00	B	3	30,000	10	1¼	654.3	20.1	3.3	195	131	11.7	58.5	*e*	none	1	79.9	83.1	290	130,669	....	11.09	....
22	5.00	B	2	100,000	13	1¼	1633.6	15.5	4.6	172.7	137.1	16.2	53.7	*e*	none	10	69.8	74.3	97.9	116,729	....	7.1	....
23	6.00	C	4	400,000	7¼	4½	2570	19.1	5.9	194	141	12.7	53.2	*g*	spec.	0	76.1	79.9	94	556,923	3.71	9.02	96.9
24	6.00	C	4	400,000	7¼	4½	2570	17.7	6.5	191.8	144	13.1	58.7	*g*	spec.	0	77.7	81.7	94	553,877	3.95	8.98	97.5
25	6.06	C	4	400,000	7¼	4½	2410	17.9	4.6	188.8	131	12.7	65.4	*g*	spec.	0	80.6	84.6	76	450,293	3.69	7.71	97.5
26	6	C	4	275,000	7¾	3	1940	9.4	4.0	199.3	132	14.9	52.3	*f*	spec.	0	71.6	75.8	62	264,780	....	5.68	....
27	7.13	D	4	400,000	....	....	4000	17.9	5.2	205.0	141.8	11.6	47.3	*f*	note 3	3	75.5	78.9	138	837,836	4.21	7.34	97.2
28	6.03	D	4	400,000	....	....	4000	17.9	4.9	207.7	136.9	12.6	46.2	*f*	note 3	2	72.7	76.7	124	748,958	4.24	7.76	94.8
29	6	D	4	400,000	....	....	4000	18.1	5.2	208.8	132.6	12.8	45.4	*f*	note 3	0	71.8	75.5	131	790,172	4.28	8.23	93.3
30	4	D	3	200,000	23	....	2112	14.8	2.3	212.2	125	16.5	46.2	*f*	none	....	64.3	68.5	93	191,585	2.91	7.77	86.5
31	5	D	3	200,000	23	....	2112	13.6	2.3	213	123.1	15.2	50.1	*f*	none	....	69.7	73.9	95	247,400	3.09	7.81	90.6
32	5.87	D	3	145,000	26	2	....	18	3.6	175.4	124.5	16.5	54.3	*f*	none	1	69.7	74.3	85	173,133	....	6.26	....
33	6	E	3	220,000	4	2	3054	14.6	4.6	171	136	14.9	58	*f*	Fig. 6	1	75.4	78.8	105	338,859	2.49	6.27	97.4
34	5.39	E	3	.....	4	2	2683	11.06	5.0	184.6	129.2	15	51	*f*	note 4	2	70.6	74.8	.....	190,517	....	4.4	....
35	4	E	3	.....	4	2	2683	6.07	3.2	179	....	14.7	50.8	*f*	note 4	7	73	75.2	.....	156,176	....	5.3	....
36	6	F	2	.....	4	2	1003.1	24	30.0	204.4	....	15.2	45.3	*e*	*a*	0	66.5	70.5	.....	73,502	....	6.11	....
37	6	F	2	.....	4	2	1007.0	24	30.0	192.6	....	15.9	46.2	*e*	*a*	1.5	65.6	69.8	.....	77,161	....	6.43	....
38	5.09	G	4	290,000	4	2	1529	15.4	5.8	188.1	147.4	15	64.2	*e*	Fig. 7	3	76.7	81.2	51	206,917	....	5.95	....

* *a* — through shell at side: *b* — through top tube sheet; *c* — direct to condenser; *d* — body to body; *e* — pumps, each body; *f* — siphon, body to body, *g* — barometric leg pipe.

Note 1 — vented through 12⅛6-in. holes direct to vapor space.

Note 2 — centrifugal pumps, each body.

Note 3 — 2-in. vents at side, bottom and top, body to body.

Note 4 — see Fig. 6.

lating "equivalent juice treated with 75 per cent evaporation" (see Table 1).

Boiling temperature, first body, deg. fahr	194.07
Temperature juice entering first body	172.71
Temperature rise	21.36
Specific heat juice entering	0.889
B.t.u. per hour, first body, for heating 41,832 × 21.36 × 0.889	794,349
Latent heat at 194.07 deg	981.35
Equivalent evaporation, lb., $\frac{794.349}{981.35}$ =	809.4
Total per 24 hr., lb	19,425.6
Actually evaporated per 24 hr., lb	605,174.4
Equivalent, had all heat been expended in evaporating, lb.	624,600.0
Equivalent gallons at 194 deg	73,456.3
Equivalent juice at 75 per cent evaporation, 73,456 ÷ 0.75 =	97,941.0
Rated capacity, gallons per 24 hr	100,000
Per cent rated capacity actually developed	97.9

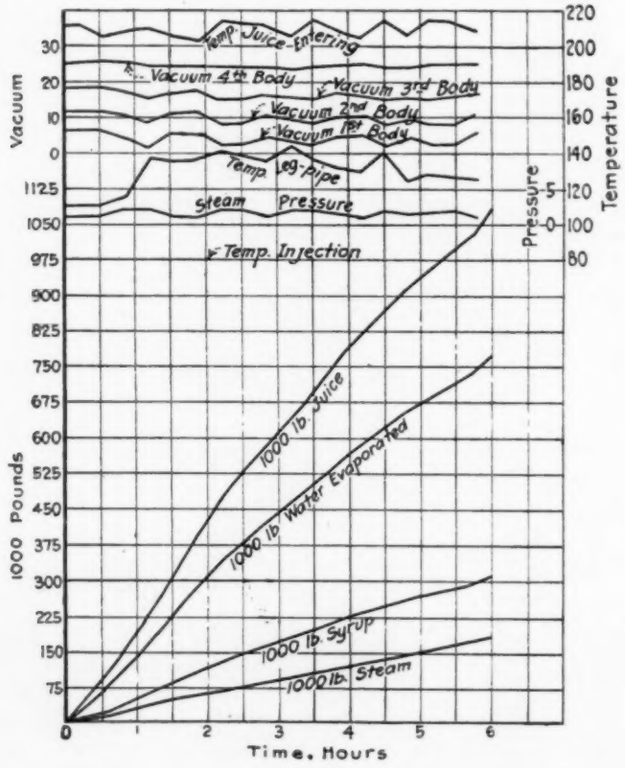

FIG. 8 GRAPHICAL LOG OF TYPICAL EVAPORATOR TEST

The term *thermal efficiency* (Table 1, last column) is used to indicate the heat efficiency of the evaporator as a whole. It may be determined by dividing the actual weight of water evaporated per pound of steam supplied by the theoretical weight of water that would be evaporated per pound of steam supplied were there no heat losses.

In order to illustrate the method used in calculating efficiency, the following example is worked out for a double effect. The general data used in working out the heat balance on which the efficiency determination is based are:

Total juice fed, lb	94,706.9
Total steam condensed, lb	36,302.0
Brix of juice entering	12.2
Specific heat [1]	0.919
Temperature juice entering	186.06
Calandria, first body	
Steam pressure, lb. abs	15.46
Steam temperature	214.56
Total heat above 32 deg	1,151.33
Juice side, first body	
Vapor pressure, in. merc. abs	25.65
Vapor temperature	204
Total heat above 32 deg	1,147.3
Latent heat above 32 deg	975.18
Juice side, second body	
Vapor pressure, in. merc. abs	7.94
Latent heat above 32 deg	1,006.2

[1] The values for specific heat of sugar solutions with varying density were taken from Kopp's tables.

The heat balance was calculated as follows:

First Body

B.t.u. entering in steam, 36,302 × 1,151.33 =	41,795,581.6
B.t.u. entering in juice, 94,706.9 × 154.06 × 0.919 =	408,710.8
Total	55,204,292.4
B.t.u. leaving in condensation, 36,302 × 182.56 =	6,627,293.1
B.t.u. in juice in body, 94,706.9 × 0.919 × 172.32 =	14,997,981.6
Sum	21,675,274.7
B.t.u. leaving in vapors (55,204,292.4 — 21,625,274.7) =	33,579,017.7
Vapor leaving, lb., 33,579,017 ÷ 975.18 =	34,433.7
Juice to second body, lb., 94,706.9 — 34,433.7 =	60,273.2
Brix of juice entering second body, $\frac{94,706.9 \times 12.2}{60,273.2}$ =	19.17
Specific heat at 19.17 Brix	0.874

Second Body

B.t.u. entering in vapors, 34,433.7 × 1,147.4 =	39,510,260.4
B.t.u. entering in juice, 60,273.2 × 172.32 × 0.874 =	9,077,606.8
Total	48,587,867.2
B.t.u. leaving in condensation, 34,433.7 × 172.32 =	5,933,615.2
B.t.u. in juice in body, 60,273.2 × 120 × 0.874 =	6,321,453.2
B.t.u. leaving in vapors	36,332,798.8
Vapors leaving, lb., 36,332,798.8 ÷ 1006.2 =	36,108.9
Juice leaving second body, lb	24,164.3
Brix leaving second body, $\frac{60,273.2 \times 19.17}{24,164.3}$ =	47.8
Total water evaporated, lb., theoretical, 34,433.8 + 36,108.9 =	70,542.7
Per cent of total evaporation, in first body	48.8
Per cent of total evaporation, in second body	51.2
Total water evaporated (theoretical) per lb. of steam 70,542.6 ÷ 36,302 =	1.9432
Total water evaporated (actual) per lb. of steam	1.9108
Thermal efficiency $\frac{1.9108}{1.9432}$ 100 =	98.33

HEAT BALANCE OF DOUBLE EFFECT

Heat entering in steam, B.t.u.	41,795,581.6
Heat entering in juice	13,408,710.8
Total	55,204,292.4
Heat leaving in condensation, first body	6,627,293.1
Heat leaving in condensation, second body	5,933,615.2
Heat leaving in vapors, second body	36,332,798.8
Heat leaving in syrup, second body	6,321,453.2
Total	55,215,164.3

The coefficient of heat transmission, the B.t.u. transmitted per square foot of heating surface per hour per degree difference in temperature, is obtained for each body by dividing the heat in B.t.u. transmitted during the test by the number of hours, by the number of square feet of heating surface and by the apparent temperature fall in that body. The coefficients of heat transmission obtained in the tests are given in the paper for each body, also the average for all bodies. As the apparent temperature fall was used, the coefficients are termed *apparent*.

The coefficients for all tests are plotted against pressure of steam in Fig. 9. The variation is shown to be very wide, the principal value of this plot being to fix limits. Similarly Fig. 10 gives the results of the laboratory tests given in the former paper. It will be noted that the coefficients for the laboratory tests are higher than those from the full size factory evaporators. This is doubtless due to the fact that the heating surface in the laboratory apparatus was always clean, and that there was a better distribution of steam with the smaller calandria. Some of the tests were made with the apparatus operating under conditions so poor that to consider the data from them in comparing types would be unfair. In nearly all cases

the tests were made without special preparation, the time since cleaning, etc., varying considerably. It is interesting to note that the coefficients obtained are higher than with ordinary surface condensers and equally as high as with modern types of high vacuum surface condensers.

Table 2 gives the coefficients for each body for quadruples of the different types. Table 3 gives the average, maximum and minimum coefficients for each type taken from the same tests. It will be noted that the highest actual coefficients were

TABLE 2 COEFFICIENT OF HEAT TRANSMISSION

(ACTUAL)

Type	1st Body	2d Body	3d Body	4th Body
A	410	340	265	145
B	400	330	240	135
C	680	630	525	220
D	430	395	320	180
F	685	400	...	...
G	682	571	365	138

obtained from type F (atmospheric double effect). These high coefficients were doubtless due to the high steam pressure and the corresponding high density of the steam. As *apparent* temperature fall was used in determining the coefficients, they not only indicate the relative heat transmitting ability of the heating surface in the different types, but include also the effect of peculiarities due to type, such as hydrostatic head, method of removing condensation, method of venting, etc. It will be noted that the film evaporators (types C and D) gave coefficients considerably higher than did the submerged tube types.

Comparing types A and B it will be noted that the latter has some advantage, the average actual coefficient for type B being some 8 per cent greater than the average for type A. The tests of type E show an average coefficient of 248, which is some 25 per cent greater than the average for type A. Comparing types C and D, the average coefficient for the former is 392 which is some 47 per cent greater than that of the latter. Type C requires centrifugal circulating pumps for handling the juice, something not required by other types. Tests of motors driving these pumps showed 0.1 h.p. per 1000 gal. of juice treated per 24 hr. This should be kept in mind in comparing this type with others. Only one test was made upon type G and this under conditions which could hardly be called favorable, the amount of juice supplied being far below its rated capacity and the juice head greater than would have been used had it been operated with an amount of juice nearer its normal capacity.

With type A only four evaporators out of a total of eleven gave coefficients above 200. In these four the conditions of operation were fair as regards cleanliness, drainage and venting. The number of days since cleaning is given in the paper for each test, though this can hardly be relied upon to give an accurate idea of the condition of the heating surface, for the reason that all of the evaporators had not been cleaned with equal thoroughness. In practice, the time consumed in boiling out, also the strength of the soda and acid, vary greatly. In some cases, the thoroughness of cleaning is not sufficient to

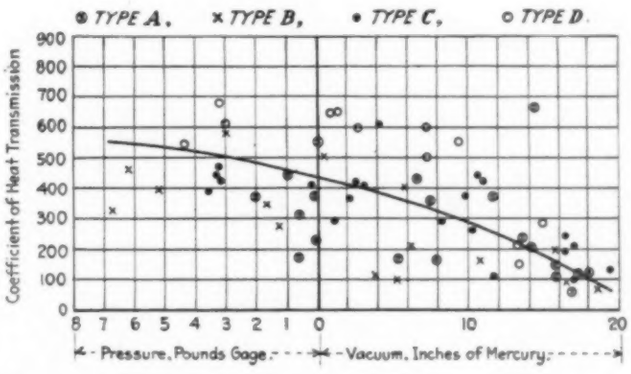

FIG. 9 COEFFICIENTS OF HEAT TRANSMISSION, ALL TESTS ON SUGAR HOUSE EVAPORATORS

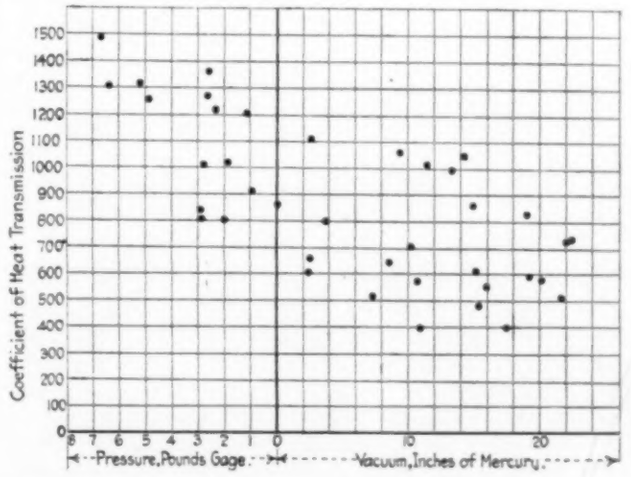

FIG. 10 COEFFICIENTS OF HEAT TRANSMISSION, LABORATORY TESTS

TABLE 3 COEFFICIENT OF HEAT TRANSMISSION

(ACTUAL)

Type	Average	Maximum	Minimum	No. of Tests Included in Average	Relative Coefficient (Actual) Standard = 100	Relative Coefficient (Corrected) Standard = 100
A	197	289	172	7	100	100
B	213	291	130	5	108	74
C	392	449	334	3	199	160
D	266	353	190	6	135	119
E	248	284	190	3	126	180
F	503	509	498	2	255	131
G	293	...	...	1	149	139

prevent a progressive fouling of the heating surface toward the end of the season.

It will be noted that practically all of the tests on type A were made with very low steam pressure in the first body, usually near atmospheric pressure, and in some cases, less than atmospheric pressure. With most of the other types, the pressure was higher, which puts type A at a disadvantage in making comparisons with the average coefficients given. According to laboratory tests, the coefficient of heat transmission varies according to the expression $U = 225 + 17{,}500\ D$, where D = density of heating steam in pounds per cubic

foot. This formula was used in calculating the *corrected* coefficients given in the last column of Table 3. These *corrected* coefficients may perhaps give a better means of comparing types than the actual coefficients, especially as regards types A and B. However, too much dependence should not be placed on these *corrected* coefficients, as the correction formula was determined from laboratory experiments.

Considering the four tests giving the highest coefficients for types A and B, the rating is:

(Actual)

Type A.....	100
Type B.....	106

(Corrected for difference in initial steam pressures)

Type A.....	100
Type B.....	96

The fairest comparison of types C and D will be obtained by using only tests 23 to 25 and 27 to 29, which were made on

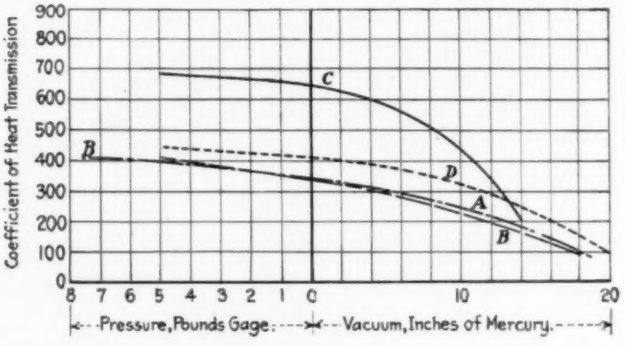

FIG. 11 COMPARISON OF HEAT TRANSMISSION COEFFICIENTS, TYPES A, B, C AND D EVAPORATORS

evaporators at the same factory and where the operating conditions were equally favorable.

(Actual)

Type C.....	117
Type D.....	100

The evaporators of type B were of two classes, namely, *a* with small tubes (¾ in. and ⅞ in.) and *b* with larger tubes (1¼ in.). Tests 15 and 16 with small tubes, and tests 20 and 21 with large tubes, were made under conditions that should afford a fair comparison. The ratings are:

(Actual)

Small tubes.....	100
Large tubes.....	142

(Corrected for difference in initial steam pressures)

Small tubes.....	100
Large tubes.....	111

RATE OF EVAPORATION PER SQUARE FOOT OF HEATING SURFACE PER HOUR

So far all comparisons have been made in terms of the coefficient of heat transmission. The unit "pounds of water evaporated per square foot of heating surface per hour" is convenient for rating evaporators, and is fairly satisfactory provided the steam pressure and the vacuum do not vary greatly. Table 4 gives averages of water evaporated per square foot of heating surface per hour for each type tested. The *actual* values do not furnish a fair comparison on account of the widely varying steam pressure and vacuum. An attempt has been made to determine the equivalent evaporation that would have resulted had all tests been made with a steam pressure of 5 lb. gage in the first body and a vacuum of 26 in. in the last body. This equivalent value is termed *corrected* water evaporated per square foot of heating surface per hour. The method of calculating the *corrected* value is as follows:

For example, in test 27, the total temperature fall for the conditions of the test was 87 deg. and for the *corrected* conditions 102.5 deg. were assumed. The actual average coefficient for the conditions of the test was 325, and for the *corrected* conditions 343. The *corrected* rate sought is

$$\frac{8.75 \times 102.5 \times 343}{87 \times 325} = 10.7$$

It is not claimed that these *corrected* values can be absolutely accurate, but rather an approximation to the results that would be obtained with the conditions assumed.

THERMAL EFFICIENCY

In thirteen of the evaporator tests recorded in Table 1, the condensed steam from the first body was weighed. Partial data regarding steam consumed for these tests are given in the same

TABLE 4 WATER EVAPORATED PER SQUARE FOOT OF HEATING SURFACE PER HOUR

FROM TESTS PLOTTED IN FIGURES IN THE PAPER

TYPE	ACTUAL EQUIV. TO 75 PER CENT EVAP.			CORRECTED 5-LB. GAGE AND 26-IN. VAC.		
	Maximum	Minimum	Average	Maximum	Minimum	Average
A Quadruple....	.....	.....	5.55	.....	.....	6.18
A Triple.....	8.31	5.07	6.56	10.8	8.15	9.2
A Double.....	11.64	7.20	9.42	19.4	13.6	16.7
B Quadruple....	7.89	4.82	5.89	5.61	3.87	4.55
B Triple.....	11.18	11.18	11.18	12.61	10.68	11.49
C Quadruple....	9.20	7.90	8.75	11.42	9.56	11.05
D Quadruple....	8.75	7.75	8.21	10.87	9.45	10.05
D Triple.....	7.38	6.62	7.11	9.6	7.45	9.21
E Triple.....	6.33	4.85	5.46	10.63	27.65	16.93
F Double.....	6.74	5.43	6.085	17.8	17.0	17.4
G Quadruple....	.....	.....	6.092	.....	.....	9.67

table. Table 5 gives more complete data relating to steam consumption in these tests.

The factors which affect the weight of steam required to evaporate a given weight of water are: *number of bodies; radiation losses; losses due to vents; method of handling condensation; temperature of juice entering.*

One pound of steam entering the first body of a multiple evaporator causes the evaporation of approximately 1 lb. of water in each body, that is, 1 lb. of steam evaporates approximately 2 lb., of water in a double effect; 3 lb. in a triple effect; and 4 lb. in a quadruple effect. This relation does not hold exactly, for reasons which will be discussed later.

The loss due to radiation varies directly as the difference between the temperatures inside the evaporator and the atmosphere outside. This temperature difference is of course greater with atmospheric evaporators than with vacuum evaporators. It is also greater in the first body of a vacuum evaporator than in succeeding bodies. The radiation loss also varies directly

as the ratio of radiating surface to water evaporated. This ratio will be less with large evaporators than with small ones, and is affected by type also. Reference to Table 5 will show something regarding the value of this ratio for the evaporators tested. Naturally the radiation loss is affected by the kind and amount of insulating covering used. The loss due to radiation in the first bodies of an evaporator is multiplied; for example, the loss from the first body of a quadruple is multiplied by 4; that from the second body is multiplied by 3, etc. In view of this, it is evident that the total radiation loss from a quadruple will be greater than that from a triple, etc., other conditions being the same. A theoretical calculation will show that this loss should be relatively small. A rough calculation based on an average coefficient of radiation of about 2.8 B.t.u. per square foot of radiating surface per hour per degree called to the fact that this has been attempted in types C, E, F and G.

Of the three general methods of handling the condensed steam from exaporators, *b* (see footnote, Table 1) evidently should be most economical for the reason that all of the condensation leaves the last body at the lowest possible temperature, the saving due to this arrangement being multiplied in all except the last body. It is common practice to use the condensation from the first body for boiler feed, though theoretically it would pay to run this water from body to body along with that from later bodies.

Primarily, evaporators are designed to vaporize water, though, in fact, some heating is generally done in the first body because the temperature of the juice entering is lower than that of boiling. It is evident that the amount of heating

TABLE 5 DATA FROM TESTS RELATIVE TO ECONOMY

SEE FOOT NOTES, TABLE 1

Test No.	Type	No. of Bodies	Rated Capacity, Gal. per 24 hr.	Actual Capacity, Per Cent of Rated	Radiating Surface per 100,000 Gal. per 24 hr., Actually Evaporated, sq. ft.	Portion of Radiating Surface Covered, Per Cent of Total	Steam Temperature 1st Body, Deg. Fahr.	Method of Venting	Method of Removing Condensation	Steam * Supplied to 1st Body for Heating Per Cent of Total	Water Evaporated per Lb. of Steam, Lb.	Thermal Efficiency, Per Cent
7	A	2	125,000	145	.....	.....	212.5	*cd*	*e*	−6.13	2.09	94.5
14	B	4	145,000	109	1921	73.50	234.9	*d*	note 2	8.9	3.53	85.1
15	B	4	145,000	174	1207	73.50	232.8	*d*	note 2	5.89	3.7	89.1
17	B	4	250,000	86	1780	0	224.5	*e*	*e*	11.73	3.4	90.5
23	C	4	400,000	94	832	100	225.4	spec.	*g*	8.06	3.71	96.9
24	C	4	400,000	94	832	100	221.5	spec.	*g*	7.83	3.95	97.5
25	C	4	400,000	76	1026	100	222.0	spec.	*g*	9.67	3.69	97.5
27	D	4	400,000	135	694	95	222.0	note 3	*f*	1.19	4.21	97.2
28	D	4	400,000	124	774	95	222.1	note 3	*f*	−0.50	4.24	94.8
29	D	4	400,000	131	734	95	222.8	note 3	*f*	−2.37	4.28	93.3
30	D	3	200,000	93	946	0	212.4	none	*f*	−12.98	2.91	86.5
31	D	3	200,000	95	923	0	208.3	none	*f*	−9.85	3.09	90.6
33	E	3	220,000	105	990	40	211.9	Fig. 6	*f*	7.46	2.49	97.4

* Minus values are for initial juice temperatures higher than the boiling temperature.

fahrenheit difference shows the following losses in percentage of the heat delivered in the steam to the first body:

	Uncovered	Fully Covered	Three-fourths Covered
Double.....	1.06	0.26	0.46
Triple.....	4.2	1.05	2.07
Quadruple.....	9.8	2.7	5.0

These figures are for a 10-ft. standard effect including the vapor pipes, with steam at 5 lb. gage and a vacuum of 27 in.

Primarily, vent pipes are for the purpose of removing incondensable gases only. If this were carried out, the vent losses would be small, in fact they are probably small in general practice, even though some steam is vented with the gases. This loss, like the radiation loss, is multiplied for all bodies except the last. The vents may be connected to the next body or to the condenser direct. The former is probably more economical, though the latter is better as far as heat transmission is concerned. This loss is apt to be greatest in the early bodies, especially if the vent openings are too large. In order to reduce losses due to venting, it is important to design evaporators so that effective separation of gases from steam may be brought about. Attention has already been done in this manner will affect the weight of water evaporated per pound of steam supplied to the first body. It should be remembered also that the steam supplied for heating in this manner does not work multiple as does that used for evaporation.

Table 5 gives the results of the tests as regards economy. It also includes information regarding the main test conditions which affect economy. A unit commonly used for measuring economy is "pounds of water evaporated per pound of steam supplied to the first body." This unit does not furnish a fair means of comparing the economy of different evaporators, however, for the reason that it does not account for variation in conditions. Thermal efficiency is more accurate, and the method of calculating this item has already been given. It will be noted that it varies from a minimum of 85.06 to 98.3, the average being 94 per cent. The table shows that the efficiency of type C was higher than type D, although the water evaporated per pound of steam supplied was greater in the latter than in the former. This apparent contradiction is due to two things: (1) the temperature of the juice entering the first body in the tests on type D was higher than in those on type C, more steam being required for heating in type C; (2) the condensation in type D was taken from body to body, begin-

ning with the second, whereas it was drained away separately from each body of type C. The low efficiencies obtained in the tests on type B quadruple, tests 14 and 15, are probably due to the small size, whereas both the C and D quadruples were of large size. Attention is called to the data in Table 5 regarding the ratio of radiating surface to water evaporated in the different types.

Type 17 on a type B quadruple evaporator gave an efficiency of 90.48 per cent. This is relatively low for an evaporator of this size and is doubtless due to the fact that it was not insulated. The low efficiencies obtained in tests 30 and 31 on a type D triple is doubtless due also to the fact that it was not insulated. These tests were made soon after the apparatus had been installed and before the covering had been applied. An inspection of this table will show the effect of high rates of evaporation in increasing heat efficiency; in fact some of the irregularity in the results can only be explained in this way.

DISCUSSION

M. B. DE PASS[1] (written). The process of sugar making is divided, we might say, into four parts:

1 Extracting, by crushing process, of juice from the cane
2 Clarification by defecation and sometimes filtration
3 Evaporation (the subject under consideration)
4 Granulation and drying.

The capacity and economy of any of the stages depends very materially on the efficiency of the preceding stage.

In some climates during the crushing stage, a larger volume of water must impregnate the crushed cane to dissolve the sugar that is not in solution. This reduces the density of the juice and increases the volume of water that must needs be evaporated from it.

One factor, the paper tells us, is the fouling of the heating surface in effects which is caused by foreign substance that has not been eliminated during the clarification stages—in fact some of it is injected during this stage; hence the amount of water added in crushing and the nature of the juice clarified entering into the effects largely determines the size and style that is to be adopted and should govern the manufacturer's guarantee.

There are two factors governing the capacity and economy of multiple effects which are not referred to in the paper. One of these is very important and that is the size of the vapor pipes and save-alls; these regulate the velocity and vapor tension and fix the boiling point in each effect. Faulty vapor pipes cause entrainment and loss in capacity.

As the efficiency of a multiple effect depends very largely on the vacuum in the last body, and this in turn on the completeness of the condensation, attention to the design of the condenser is important. Owing to the low boiling point in the last vessel, the velocity of the vapors is greater and therefore the greater the chance of entrainment. Any syrup thus carried off into the condenser is never reclaimed, as is not the case in the other vessels where the sweet water may be trapped and re-evaporated or used in the first stage of extraction for saturation. So not only is a good condenser required on the last pan but also a good save-all that will completely strain the syrup from the vapor before it enters into the condenser. The writer has seen a "save-all" that reclaimed from 200 to 300 gallons of syrup in twenty-four hours, which would have been lost if permitted to pass into the condenser with the vapors and out into the hot well.

The standard type of vertical tube submerged calandria is the most popular of all multiple evaporators, and by the aid of such papers and experiments as are being made by Professor Kerr and other prominent engineers, the manufacurers are learning how and where to overcome all defects. The vapor velocity is controlled, entrainment is prevented, perfect condensation is accomplished, air pockets are done away with and the condensed waters are properly drained from the calandrias.

In dealing with the problem of heat transmission, various means are advocated by different manufacturers. Some use baffle plates and different arrangements to control the direction of the steam, some leave out tubes, and others both. The trouble to overcome in large bodies is that some parts get more heat than others, causing unequal boiling and dead spaces in the calandrias.

In the earlier apparatus, steam was admitted around a circular steam jacket, on the outside of the calandria, and the drains were also on the outside directly under the steam entrance. The consequence was that all the ebullition or boiling took place on the periphery of the calandria where the heat remained and a dead space formed in the center. Mistaking the ebullition at the periphery, caused by the heat remaining at that point, for circulation, someone conceived the idea that if there was a central down-take to aid the circulation of the liquid to work from the center to the periphery, that would aid the evaporation; and on experiment it apparently proved a success and the liquid actually appeared to work down through the down-takes and up through the tubes from center to circumference, while the fact of the matter was that the down-take filled the void and dead space in the center of the calandria, and it was still found that there was air and gas pockets in the center of the calandria which retarded exaporation. Something had accordingly to be done to relieve this and make the vapor, or steam, find its way to the center, this brought about the use of baffle plates, or deflectors, arranged so as to admit the vapor at one side and deflect it around in two directions to the other side, and thence to the center, as shown in Fig. 6 of the paper.

This was tried years ago at the American Sugar Refining Co.'s Plant in the city of New Orleans, where one of its Standard Triple Evaporators was equipped with deflecting plates, exactly as shown in Fig. 6. The plates deflected when the steam was first turned on, but after the entire calandria is filled, the pressure becomes equal and the plates of no further use.

In connection with these plates, however, the drain, gas and air pipes are connected as near to the center of the calandria as possible, where a partial vacuum is formed causing the removal of the pocket, or dead space, and the steam to be drawn to the center; thus utilizing heating surface that heretofore was idle and now becomes effective. Large 16-ft. diameter effects, built last year in Cuba, without the plates, but with the drains to sweet-water pump, also gas and air pipes all connected in the center of the calandria, have proven by good results that plates are not necessary.

From 1834, when Norbert Rillieux invented and put into use in Louisiana the first multiple evaporator, which was of the horizontal type, to the present day, many changes have taken place in the design and style, economy and efficiency, all of which are fast coming to perfection through the efforts of learned and practical men, who give the results of their labors to the trade and craft.

Professor Kerr has given us tests taken on, most, if not all

[1] c/o The Payne & Joubert Mch. & Fdy Co., New Orleans.

of the various types of evaporators now on the market. It is hard to form a comparative conclusion as conditions alter and govern each test, which is proven by the fact that the same man on the same type of machine obtains different results at different centrals. The rating of any evaporator is computed by the number of pounds of water-evaporation per square foot of heating surface as a basis. A multiple of four, or a quadruple effect, is now conceded to be the most economical and is being adopted by most all large houses. The following list shows how even the test of different experts varies in a quadruple effect:

Hausbrand	5.2 lb. per square foot
Kerr	5.5 lb. per square foot
Jones & Scard....	6.0 lb. per square foot
Wallis & Taylor...	7.5 lb. per square foot
Hind	8.0 lb. per square foot
Deerr	9.0 lb. per square foot

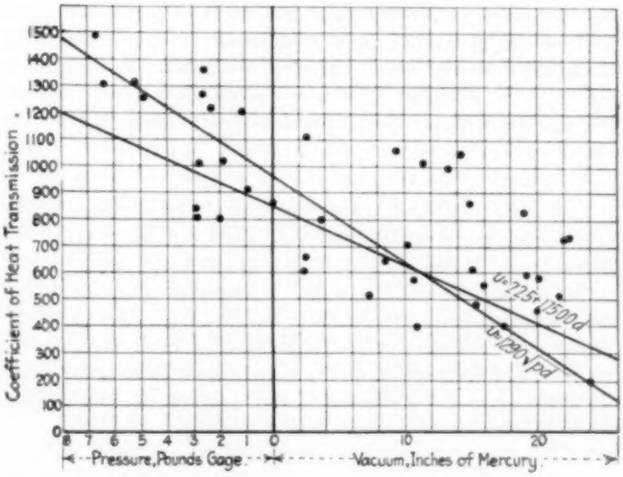

FIG. 12 COMPARISON OF AUTHOR'S AND PARR'S FORMULAE FOR COEFFICIENT OF HEAT TRANSMISSION

We are indebted to our great Louisiana State University for the interest it is taking, through Professor Kerr, in carrying out such tests as are described in the paper, which are of so much value and interest to all concerned.

GEORGE A. ORROK (written). Professor Kerr has undertaken the investigation of one of the most complicated problems in the heat transmission field, and the results obtained show the difficulties which he has encountered. Theoretically, the case is that of the transfer of latent heat, introducing two changes of state, in consequence of which both upper and lower temperatures are constant and fixed by the pressures employed. The question is complicated by the presence of both air and water films on the gas side, with approximately similar conditions on the liquid side of the tube walls. Moreover, there is lack of control of film thickness because the circulation is negative or self induced, and an increase of certain film thickness (i.e. gas on the water side and water on the gas side) with an increase of circulation. When we added to this the scale and oil troubles on the gas side of the tube and the gumming of the surface from impure juice on the liquid side, it seems remarkable that so consistent results should have been obtained.

The author has plotted in Fig. 10 the results of all his laboratory tests given in his former paper. I have plotted (Fig. 12) across these points the line $U = 225 + 17500\ d$ which he has given as best representing them. I have also plotted a line $U = 1{,}290\ \sqrt{\ }\ pd$, Parr's[1] formula, in which the coefficient was obtained from the author's figures. These two lines cross at approximately 706 B.t.u. and 8 in. of vacuum. It would appear that variations as wide as 800 to 1370 B.t.u. at about 3 lb. per sq. in. pressure and 400 to 1070 B.t.u. at 10 in. of vacuum could hardly be expressed by either curve, and therefore the use of either as a correction formula would be inadmissable.

It is curious that all the performance curves in the paper inclusive cut the X-axis to the left of 22 in. of vacuum.

While the author has done some exceedingly good work in these tests of multiple effect evaporators which will enable the designer better to meet the demands upon this type of apparatus, the heat transmission problem for this particular case is likely to be troublesome for some time to come. It is highly probable that consistent results with multiple tube apparatus are only accidental and the simplest apparatus that will give the proper conditions will usually give the most consistent results.

CLARK D. LIBERMUTH.[2] The fouling of the heating surface by scaling is one of the most important of the practical considerations of the sugar apparatus.

Although it has been known that pressures above the atmosphere can be used in the first body of the evaporator, the high pressure has been brought into use only recently. At present in Cuba there are many evaporators in which steam under pressure is used in the first body. There being no sulphuration and little liming, no difficulty is met with. These higher pressures are now being used in Louisiana. More scale will be precipitated in the first body due to the higher temperature which may result in fouling the first body and cutting down the steam supply. The author is asked to investigate the effect of this condition in the first body with the Louisiana juices of high salt content.

Last year a rather peculiar situation presented itself over the State as a whole. The juices were of a higher purity than normal, yet the boiling took a longer time. There was general complaint. It was found, however, that the proportion of salts was much higher than usual, resulting in a high boiling point. The author is asked to investigate the relative effects of dissociable salts and organic compounds upon the elevation of the boiling point.

W. H. P. CREIGHTON.[3] I agree with Mr. Orrok, that the question before us is extremely complicated. The theory of an engine condenser is simplicity itself when compared with that of the multiple effects used in the evaporation of sugar juices. The evaporation of sugar juices is an extremely important problem to us in Louisiana. Ten cubic feet of juice in the multiple effect will evaporate to two cubic feet, and in the vacuum pan will evaporate to one cubic foot. This cubic foot is an half and half mixture of molasses and sugar, and the apparatus must be designed to boil this mass. A 1,000-ton house will have about 1,000 tons of juice to get rid of, because maceration water and milk of lime will be added to the juice to be evaporated. To evaporate this water economically is a problem. There are temperature limitations; too high a temperature will spoil the sugar, while the low temperature is limited by the amount of vacuum obtainable. The *apparent* range is about 103 deg. But this is only ap-

[1] On the Theory of Multiple Evaporators, P. H. Parr, The Engineer, London, Feb. 18, 1916.

[2] Lauderdale P. O., Louisiana.

[3] 1445 Henry Clay ave., New Orleans, La.

parent. The difference in temperature in the first body, added to that in the second and in the third will not total 103 deg., because sugar solutions and water do not boil at the same temperature, under the same pressure. Then there is the loss due to hydrostatic head, the difference in juice height, which increases the pressure on the juice at the bottom of an effect. Hence, in the triple effect, 2 or 3 deg. may be lost in the first body, 4 or 6 in the second, and 10 or 12 deg. in the third. These added together reduce the apparent temperature range materially.

Table 1 may be correctly interpreted only by an expert in order to determine which of several causes were responsible for the variance in the amounts of water evaporated per sq. ft. of heating surface in evaporators of the same type. Different evaporators working under identical conditions will give different results. Personally, I am very much interested in the evaporator in Fig 6, as it was due to a suggestion of mine that Mr. Weber designed it. The entering steam was to sweep over tubes through a gradually diminishing area to maintain its velocity and keep the air moving with it to the very end where it is taken out by an air pump. In the ordinary standard evaporator, there is no way of telling if the air is being removed. There is violent evaporation in spots, indicating inefficiency, as the heat transfer is confined practically to such spots and they need high temperature differences to be effective. Whereas if the air is removed and the steam sweeps through a fixed channel, a less temperature difference will be necessary in the evaporator. This is illustrated in experiment 35, Table 1. Here the pressure in the first effect is only 6 lb. per sq. in. absolute, and in the last is 3 lb. per sq. in. absolute, a total pressure difference of only 3 lb. per sq. in This means that if the amount of steam admitted to the first effect had been large enough, the pressure would have been greater and hence there would have been a greater capacity. The author should say that capacity depends upon *three* factors: *quantity of heat supplied to the first effect*, coefficient of heat transmission and temperature fall. Scientific research in this field, considering each of the problems separately and as they affect the whole, is going to be of great value to the manufacturer and should result in the saving of an enormous amount of copper in the construction of evaporators.

E. H. ROUSSEAU.[1] I had the pleasure of making experiments on a small experimental evaporator with Mr. A. L. Weber. Heat transmission depends upon a difference in temperature. For an effective temperature drop from one side of the tube to the other, there must be a rapid replacement of the hot particles of juice by colder particles, so that the more rapidly cold juice can be brought to the heating surface, the more rapid will be evaporation. I refer you to evaporator D for the juice side of the evaporator and to evaporator E for the steam side. These I wish to combine in evaporator A which is our standard evaporator.

Viscosity increases with the concentration of a solution. As the viscosity increases, the size of bubbles formed in ebullition becomes greater in proportion to their weight and they are carried along more rapidly with the vapor currents formed. In the first body of a quadruple effect evaporator will be found conditions of high temperature and low density of juice. This is favorable for heat transmission. In the last body the conditions are low temperature and high density of juice. This is not favorable for heat transmission, but as the viscosity of the juice is high, the upward velocity of its bubbles is high and the temperature differences between the sides of the tubes are great, equalizing the rate of evaporation in the last with that of the first body.

In making these experiments, there was used an evaporator with a steam belt 2 ft. in diameter and 3 ft. high, with 2 in., No. 17 gage, standard copper tubes. Steam was under 10 lb. per sq. in. pressure and juice under atmospheric pressure. Steam distribution was as given in type E. With each new density, the level of the juice was varied from 0 to 36 in., and it was found that at 6 deg. Brix, the highest rate of evaporation was when the liquor was at $^1/_3$ the height of the tube. At 55 deg. Brix, the highest rate was with the liquor at $^1/_9$ the height of the tube, showing that with equal conditions of temperature, the density and viscosity of the juice increasing gave better results with a low height of liquor.

In these tests, steam was used. The air eliminator was closed; the heat transmission was 250 B.t.u. Opening the air eliminator and drawing out all of the air, the heat transmission was increased to 1000 B.t.u., an increase of 400 per cent. Uniform steam pressure can be maintained by high velocity of steam, by means of baffles, or by removing some of the tubes at the entrance, allowing the steam to enter the bulk of the heating surface, a pocket being provided from which to draw the air.

LEO LOEB (written). Another application of the multiple effect evaporators is the use for producing fresh water for drinking or boiler feed purposes from water containing a large amount of soluble salts. Compared with the sugar evaporators, the coil pressures in the first stages are generally higher, the heating surface is seldom, if ever, totally submerged, and the removal of the concentrated brine is governed by considerations of capacity and fouling of the heating surface and shell in contact with the brine.

The purity of the fresh water should be such that less than one grain of chlorine per gallon can be detected by the silver nitrate test. It is therefore necessary in some types of commercial evaporators to expose a portion of the heating surface, slightly heating the ascending vapors, and giving the particles of solid salt an opportunity to separate. However, if proper attention be given to baffle and separator design, it is possible to operate the evaporator with submerged heating surface at high rates of evaporation and obtain distillate of required purity.

The usual installation on shipboard consists of duplicate sets of three evaporators, so piped as to be operated in triple effect or single effect, depending upon the immediate demand for fresh water.

Of the various factors mentioned in the paper as affecting the capacity of evaporators, the most important in the design and operation of salt water evaporators are:

5 Presence of condensation on the heating surface,
8 Cleanliness of heating surface (liquor side),
14 Density of liquor being boiled.

Air and other incondensable gases have less effect in the salt water evaporator where higher steam pressures are used than in the sugar evaporators under vacuum, providing they are not permitted to blank off a portion of the heating surface.

The great loss in capacity due to condensation on the heating surface was clearly illustrated by recent tests on two horizontal tube evaporators. One consisted of 1½ in. brass tube heating surface arranged in eight horizontal rows and connected by return bends. Thus the condensate traveled the entire length of the eight tubes before being vented, with the result that the

[1] c/o Dibert, Bancroft and Ross Co., New Orleans, La.

coefficients of heat transmission were low, ranging from 115 to 323 B.t.u. per sq. ft. per hr. per degree difference in temperature between steam at entrance to coils and vapor in shell. When operating in single effect, the temperature of condensate at the vent was from 32 to 176 deg. below the temperature of saturation of steam entering the coils, and the evaporating capacity of the heating surface was from 7.7 to 19.9 lb. of vapor per sq. ft. with brine at 180 deg. fahr.

A modified design having nine rows was provided with a header so that the condensate from any tube could reach the vent by traveling through only one cooling coil. With the same steam and vapor pressures as in the first type, the coefficients of heat transmission were from 387 to 719 B.t.u. per sq. ft. per hr. per degree temperature difference between steam at entrance to coils and vapor in shell. The amount of subcooling of brine never exceeded 90 deg. and the evaporating capacity of the heating surface was from 17.2 to 81.4 lb. of vapor per sq. ft. with brine at 180 deg. fahr.

The reduction in capacity of the salt water evaporator when the concentration of the brine is increased from twice to three times that of normal sea water is about 10 per cent, amounting to fully 15 per cent if the concentration be further increased to four times that of sea water.

It would be interesting to know how Professor Kerr calculated temperature difference. In salt water evaporators, the temperature gradients on the two sides of the heating surface are complex. A portion of the surface in contact with the heating medium destroys the superheat which may result from throttling at the inlet valve, a great portion of the area is effective condensing surface and the final portion is water cooling surface. On the brine side, these states are reversed, a part of the surface acting as feed heating surface, the major portion as evaporating surface and a small portion at times as superheating surface. Under these circumstances it has been the practice to consider temperature difference as indicated above to be the difference between the saturation of steam to coils and saturation temperature of the vapor in the evaporator body.

THE AUTHOR. I wish to call attention to the preliminary statement I made when this paper was presented—that it should be looked upon as a survey rather than as a research. The tests recorded were made on full-size sugar house evaporators operating under regular conditions, therefore there was little opportunity to control conditions as would be required for research work in the fullest sense. A former paper[1] by the author giving the results of a series of experiments on a laboratory evaporator is better entitled to consideration as research work, and I would respectfully direct the attention of Mr. Creighton, who mentioned in his discussion the need of research along these lines, to this paper. The tests recorded in the present paper give data only on the subject of rates of heat transmission, nothing having been said relative to the cost of heating surface, the cost of operation, maintenance, etc. The proper selection of an evaporator for a specific installation should of course include a consideration of all of these points.

Mr. De Pass calls attention to the loss of sugar due to entrainment. This bears on the present paper only indirectly because of the fact that, in order to separate the entrained juice, save-alls must be installed and the friction of the vapors passing through them may result in pressure losses which in turn reduce capacity by reducing temperature fall. In elaborate tests made by the author on a laboratory evaporator, data were obtained which seemed to show that entrainment is principally affected by the height of boiling and by the rate of boiling. In other words, the higher the boiling and the greater the rate of boiling, at least in the standard type, the greater the amount of entrainment. Practice seems to show that it is difficult to design save-alls that are efficient as separators that do not offer excessive friction.

Several references were made by those discussing the paper to type E, which makes use of a set of baffle plates in the calandrias to give a long and gradually narrowing steam path. This type was originally developed in Europe many years ago, but was recently introduced into this country by Mr. A. L. Weber.

It will be seen in the paper that the average coefficient of heat transmission for tests 33, 34 and 35 of type E was 248, whereas the average for the standard evaporator, type A, was 197, which seems to show that the higher steam velocity and possibly the better removal of incondensible gases due to the baffle plates have resulted beneficially. It may be well to state that this is only one of a considerable number of different arrangements of baffle plates that have been used or suggested for distributing steam in calandrias. The increase of steam velocity in such an arrangement will naturally result in pressure drop, which must be overcome by means of a pump. The power required to operate such a pump, however, is not so important in connection with an evaporator as in the case of a surface condenser for the reason that the exhaust steam from the evaporator pump can be utilized.

Mr. Orrok calls attention to the fact that all the performance curves in the paper cut the X-axis to the left of 22 in. of vacuum. I will call his attention to the fact that the coefficients plotted were *apparent*, that is, they were determined by dividing the heat transmitted by the apparent temperature fall. In other words, the temperature fall was obtained by subtracting the saturation temperature of the steam corresponding to the pressure in a body, from the saturation temperature corresponding to the pressure in the preceding body. Due to the effect of hydrostatic head, viscosity of juice, the presence of air in steam, etc., the actual temperature fall is less than the apparent fall. As is well known, also, the difference between *actual* and *apparent* fall is greater in the last bodies. Consequently a curve representing actual temperature falls would be nearer horizontal than those given in the paper. The above will answer Mr. Loeb's question, regarding the method of determining temperature fall.

The effect of juice scale, as Mr. Libermuth points out, also the effect of juice viscosity discussed by Mr. Rousseau, are important, and while some work has been done along these lines by the author, we hope to make experiments in the future that will enable us to form more definite conclusions regarding these points than we now have.

The principle upon which the Diesel engine operates has not to date been successfully adopted for use with the commercial motor truck. It is more than probable that such a development will occur, and should it do so it will provide a very useful alternative as an offset to gasoline, the cost of which for trade vehicles is a considerable item in the running expenses. There is no doubt that a vehicle propelled by an engine of the Diesel type, using heavy oil as fuel, would be a boon to users of that class of machine.

Suggested modifications of the present Diesel engine for the end in question are described and illustrated.—*The Commercial Motor*, XXIII-578, April 6, 1916.

[1] Trans. Am.Soc.M.E., Vol. 35, page 731.

ITEMS OF INTEREST

The use of aluminum when filed to a powder is little understood. In this condition it forms part of two of the most destructive of agents, one of which is known as ammonal, a mixture of five or eight parts of ammonium nitrate with one part of finely powdered aluminum, and used to charge shells. Its explosive violence is tremendous, and it is one of the few explosions that have never been used as propellants, as its suddenness would smash the explosion chamber of any gun known to warfare.—*The Brass World*, XII-5, May 1916.

From an engineering standpoint, intense heat can be used for carrying out many industrial processes to which at present other means are applied. Ordinary fuel furnaces can seldom be raised to a high temperature, but oxy-acetylene furnaces are capable of giving out great heat. One of the most interesting and industrially useful processes for which a high temperature is necessary is the fusing of quartz, which, when brought to a fluid state by means of an oxy-acetylene blowpipe, is moulded into flasks, bowls, tubes, and other vessels for chemical purposes and for domestic applications of electricity, cooking utensils, etc.—*Acetylene Lighting and Welding Journal*, February, 1916.

While the use of the electric one-direction drive for rolling mills is not new, when it comes to the reversing mill the steam engine is probably still largely considered the better adapted prime mover.

Nevertheless in a paper by William Sykes and David Hall, before the A.I.E.E. at this year's Cleveland, Ohio, meeting, on "Electric Drive for Reversing Rolling Mills" the authors state that within the last few years the electrically driven reversing mill has been considerably developed and a number of installations made with great success; and as an indication of the position which the electrical form of drive has reached, the engineers of one of the large steel companies stated that the electric drive would undoubtedly in the very near future entirely supplant the reversing steam engine, except in perhaps certain peculiar cases.—*Proc. A.I.E.E.*, XXXV-6.

Spur Gearing is the subject of a paper by Daniel Adamson, read before the Institution of Mechanical Engineers.

The difference between cycloidal and involute shapes for teeth are mentioned, the advantage claimed for the latter being that it lends itself better to satisfactory production by generating machines.

The proportions of length of tooth to pitch and also the angle of obliquity are considered.

The various materials used in the construction of gearing are named, leading up to the present practice of using steel almost universally.

Allowable working stresses are reviewed, beginning with data published by Walker in 1868, upon which were based later what is known as the "Lewis" formula. Permissible working speeds are given ranging from 600 ft. per min. up to 5000 ft. per min.—*Jour. Inst. Mech. Eng.*, May 1916.

Tests of a surface-combustion type of furnace for laboratory use were recently made by E. Schramm and J. R. Cain. Measurements were made coincidently of the consumptions of air and gas, the compositions of the flue gas, and the temperature resulting from different rates of combustion.

Observations were made of the varying temperature due to altering the ratio of air to gas.

It was clearly established that such a ratio of 5.5 gives most nearly the ideal condition of perfect combustion without any excess of oxygen; and it was seen that a 20 per cent excess of air caused a lowering of the furnace temperature of 100 deg. cent (180 deg. fahr.).

A temperature of about 1650 deg. cent. (3000 deg. fahr.) was reached in a little over half an hour and maintained for 10 minutes, when the alundum muffle caved in.—*Jour. Ind. and Eng. Chem.*, VIII-4.

Stresses in connecting rods are set forth in a paper by Lieutenant Karl F. Smith, before the American Society of Naval Engineers.

Tension stresses are not considered, failure due only to compression and the stresses of centrifugal force is dealt with.

In the plane parallel to the shaft, the rod, due to the form of the wrist and crank-pin bearings, may be considered as a column with *fixed ends*, while in the plane of oscillation it is a column with *pin ends*, and free to take up any angular position in this plane, and as all theories and experiments show that the collapsing load is much greater for fixed ends, it is necessary to consider only yielding by bending in the plane of oscillation.

Stress diagrams are given, and it is pointed out that one stress has generally been neglected, though of extreme importance.—*Jour. Am. Soc. Nav. Eng.*, May 1916.

In a lecture before The Royal Institution, Professor E. G. Coker dealt with "Polarised Light and its Application to Engineering." He said that the remarkable discovery of Sir David Brewster, made in 1816, that transparent materials when stressed became doubly refractive, might well have been more frequently pressed into service. The discoverer pointed out that the stress in arched rings of bridges could be rendered visible in a glass model.

Professor Coker stated that in applying this discovery to cases of practical importance it was evidently necessary that that material used should have physical characteristics similar to steel, iron and other materials of general use by engineers, and in this respect glass has many desirable qualities, but that little success has resulted, due mainly to the difficulties experienced in shaping glass models; but that when these are overcome the value of the information gained is very great.

Nitro-cellulose preparations afford a material having nearly all the desirable features of glass and some other properties which make it in some respects superior thereto.

The lecturer showed a model of an arch-ring which, when loaded, glowed with color in the polariscope and gave a readily interpretable picture of the state of internal stress.—*Cassier's Engineering Monthly*, vol. 49, no. 4, April 1916.

DRAINAGE PUMPING

Discussion on the Evolution of Low-Lift Pumping Plants in the Gulf Coast Country Given at the Spring Meeting in New Orleans

THE paper entitled The Evolution of Low-Lift Pumping Plants in the Gulf Coast Country, presented at the Spring Meeting held in New Orleans, April 11 to 14, by W. B. Gregory, Mem.Am.Soc.M.E., was published in the May issue of The Journal. This paper showed the part that pumping machinery has had in the development of the City of New Orleans and in the reclamation of the fertile wet prairie lands of Louisiana and Texas; also the importance of pumping plants to the rice industry of the Southwest. To this end the history of pumping in this section was briefly related and examples of typical pumping plants given.

Professor Gregory's paper, the discussion of which is here presented, related the history of low-lift pumping in the Gulf Coast country and gave examples of typical pumping plants.

The discussion supplements the author's record by examples of plants in the Upper Mississippi Valley.

It includes additional information regarding the unique low-lift screw pumps recently installed by the New Orleans Sewerage and Water Board. Each of these pumps has a capacity of 225,000 gal. per min., and the pumps have an efficiency of over 70 per cent for lifts between 3.5 and 10.5 ft.

The discussion also includes supplementary data on low-lift pump details, and considers types of pumping units other than those treated in the paper.

About ten years ago a movement was started by Edward Wisner to reclaim the wet prairie lands lying at or near Gulf level. The work is now being carried out on an extensive scale. More than a quarter of a million acres of agricultural lands have been reclaimed or are at present in the process of reclamation in the state of Louisiana. The land reclamation has been of such recent development that there is no adequate record of the magnitude of the pumping plants, such as was furnished by the Special Censors of 1910 for irrigation, and this the paper aimed to furnish.

The paper drew out some very valuable discussion, not in criticism, however, but containing supplementary data of interest and importance in connection with the author's historical record of the development of low-lift pumping machinery and his presentation of test results. The paper and discussion furnish, therefore, an adequate source of reference on reclamation work as developed in the Mississippi Valley.

DESCRIPTION BY JOHN J. HARMAN OF THE PLANTS IN THE UPPER MISSISSIPPI VALLEY

JOHN J. HARMAN (written). In the Upper Mississippi Valley drainage pumps of other than the centrifugal type have hardly been used at all, although there has been quite a variety of different kinds of prime movers. The most predominant type of machinery used in the earliest plants was the low head centrifugal pump, driven by simple slide valve engine, the steam being supplied at about 100 lb. pressure from a fire tube boiler. The machinery in these plants was far from being high grade in materials and workmanship, and often the pumps did not have sufficient capacity to handle the drainage water under wet weather conditions. Another common fault was that the power units were not properly proportioned to the loads imposed upon them, so that in some cases where the pumps were abundantly large, the engines and boilers were too small to carry the load when the river was at a high stage. Add to this unstable foundations and poor management, and we have a fair conception of these earlier plants. Some of them were complete failures, and the ones which handled the water successfully were very expensive to operate, difficult to keep in repair and, like most agricultural machinery, very short-lived. A number of these plants have been completely rebuilt, long before the bond issue covering the original cost of installation was paid off. The great benefits derived by drainage, due to the high fertility of the reclaimed lands, however, offered a reward so tempting that the development went on apace in spite of the difficulties encountered.

The quality of machinery installed has gradually improved. Centrifugal pumps especially designed to meet the peculiar requirements of this service have been developed, which show an efficiency of from 65 to 80 per cent, or even higher, throughout the working range. Careful designs of suction and discharge pipes have been made, reducing the total pipe friction and velocity head losses to a mere fraction of the losses in the earlier plants. The power producing equipment has been vastly improved, both in quality of workmanship and materials and in economy of operation. Foundation designs of a highly permanent character and fireproof building construction have been introduced.

These improvements in pumping plant construction have not been accomplished without much persistent effort on the part of the engineering profession and the more far-sighted land owners. In many cases, of course, it has not been possible to design in accordance with the dictates of engineering judgment applied to the problem on account of first cost restrictions placed by the land owners and district officers.

Although there is a rapidly growing trend toward high grade pumping plant construction, there are still a great many who willfully close their ears to the advantages of: a reduction in the perpetual yearly operating cost of 50 per cent or more; permanent foundations having a life of 100 years or more, particularly the part below normal water level, which offers great construction difficulties; a substantial fireproof building having a life of 50 years or more; high grade heavy type machinery on stable foundations, having a

life of 30 years or more; a substantial reliable confidence-breeding pumping plant, the heart of the reclamation project, which adds dollars to the value of every acre of land in the district. It is encouraging to note that during the past five or six years a number of this type of high grade pumping plants have been constructed.

As typical of these high grade plants, a brief description of three plants is given below, together with a statement of the economy guarantees and the results of the acceptance tests.

Elsberry Drainage District.—The Elsberry Drainage District is located in the State of Missouri on the west bank of the Mississippi River, about 70 miles above St. Louis, Missouri. It contains 25,000 acres of reclaimed land. About 113,000 acres of hill drainage is diverted to the Mississippi River above and below the district by means of diversion channels.

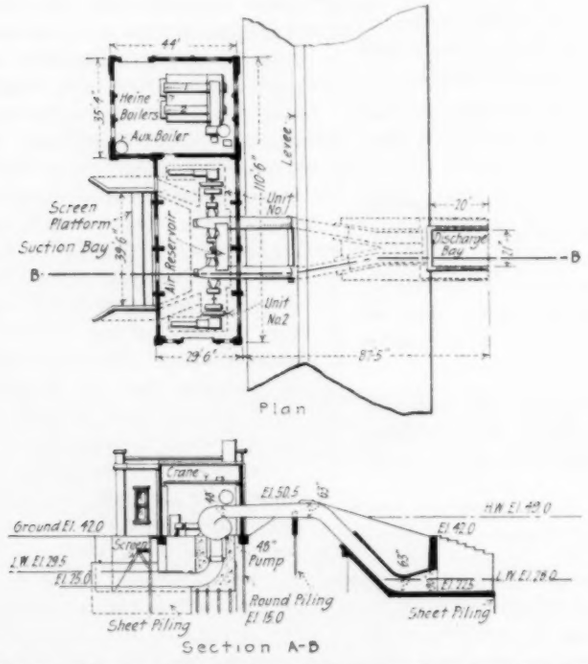

FIG. 1 PUMPING PLANT OF THE ELSBERRY DRAINAGE DISTRICT

The pumping plant contains the following principal equipment:

Two 48-in. Alberger low head centrifugal pumps
Two 21 in. x 26 in. Fleming-Harrisburg Heavy Duty Uniflow Engines
Two American jet condensers driven by silent chain drives from the main engine shafts
Two 168-h.p. Heine water tube boilers, equipped with shaking grates, soot blowers and induced draft apparatus
One Webster open feed water heater, together with miscellaneous auxiliaries and appurtenances.

Fig. 1 shows the general layout of this plant, while Fig. 2 shows on a larger scale the suction intake arrangement. Particular attention is directed to the permanent character of this design, the intakes being built in solid concrete and the discharge pipes being encased in concrete below normal water level. The friction loss in this intake is so small as to be almost unmeasurable, and the total friction and velocity head loss in the intake and discharge pipes, with the pumps operating at normal capacity, is less than one foot.

Another feature of this design is the cross-connection of the two units, so that one or both pumps may be operated from either engine. For ordinary pumping heads up to about 7 ft. both pumps are operated by one engine, thus securing much better engine economy at the low heads.

The acceptance test of this plant was made in 1915. The pumping head during the test averaged 7.52 ft., and by converting the data to guarantee conditions the following results were secured:

a	Pounds of 10,800 B.t.u. coal per acre-foot of water pumped against a 6-ft. static head	36.6
b	Pounds of 10,800 B.t.u. coal burned, per useful water horsepower	4.43
c	Contractor's guarantee: Pounds of 10,800 B.t.u. coal per acre-foot of water pumped against a 6-ft. static head	38

Muscatine-Louisa Drainage District No. 13.—The Muscatine-Louisa Drainage District No. 13 is located in the State of Iowa on the west bank of the Mississippi River, just below Muscatine, Iowa. It contains 21,400 acres of reclaimed land, and 30,000 acres of additional land drains into the district and has to be pumped. Much of the land is of a sandy nature, so that the run-off is delivered slowly to the ditches. The plant contains the following principal equipment:

Two 54-in. Worthington low head centrifugal pumps
One 36-in. Worthington low head centrifugal pump
Two 20 x 30 Filer & Stowell Uniflow engines, direct connected to the 54-in. pumps
One 14 x 30 Filer & Stowell Uniflow engine, direct connected to the 36-in. pump
Two 7-in. Schutte-Koerting Eductor Condensers
One 5-in. Schutte-Koerting Eductor Condenser
Two 200-h.p. and one 100-h.p. water tube boilers, equipped with Heine superheaters, shaking grates, soot blowers and induced draft apparatus
One Cochrane feed water heater and purifier, together with miscellaneous auxiliaries and appurtenances.

The steam is generated at 175 lb. pressure and carries 100 deg. superheat. The condensers produce a vacuum of 26 in., the circulating pumps being driven by silent chain drives from the main engines.

The general layout of this plant is shown in Fig. 3, p. 47, of the U. S. Department of Agriculture Bulletin 304.

The contractor's guarantees on the economy of this plant read as follows: The coal per acre-foot when pumping against a 6-ft. static head is estimated from manufacturer's guarantees not to exceed 46 lb., and will not in any event exceed 56½ lb. when tested as required by the specifications.

The acceptance test of this plant was conducted in June, 1915. The pumping head at the time of making the test was only about 4 ft., but by converting the data to the guarantee conditions by means of the contractor's efficiency and capacity curves, the final results secured were as follows:

a	Pounds of 10,500 B.t.u. coal, per acre-foot of water pumped against a 6-ft. static head	35.4
b	Pounds of 10,500 B.t.u. coal burned, per useful water horsepower	4.29
c	Contractor's guarantee: Pounds of 10,500 B.t.u. coal per acre-foot of water pumped against a 6-ft. static head	56.5

Fabius River Drainage District.—The Fabius River Drainage District is located in the State of Missouri on the west bank of the Mississippi River, opposite Quincy, Illinois. The district contains 14,250 acres of reclaimed land. The North and South Fabius Rivers, having a drainage area of about 1,000,000 acres, are diverted around the lower end of the district, and about 19,000 acres of hill land drainage is diverted to the river at the upper end of the district.

The pumping plant is now under process of construction, and when completed will contain the following principal equipment:

Two 42-in. Southwark double suction low head drainage pumps
Two 250-h.p. Southwark-Harris valveless oil engines (Diesel principle)
One 60-h.p. Winslow high pressure oil burning steam boiler for auxiliaries. The layout of this plant is very similar in general character to the layout of the Elsberry Drainage District plant.

While this plant has not been tested, it is expected to meet the contractor's guarantees without difficulty. The guarantees are as follows:

a	Pounds of 18,500 B.t.u. 25 deg. Baumé fuel oil, per acre-foot of water pumped against a 6-ft. static head	7.76
b	Pounds of 18,500 B.t.u. 25 deg. Baumé fuel oil burned per useful water horsepower	0.94

Another phase of the problem of drainage pumping, fully as important as design and construction, is the proper maintenance and economical operation of the plant from day to day and from year to year. Reclaimed lands of this type are encumbered perpetually to the extent of this maintenance and operation cost. Like interest, it runs on forever, but unlike interest, it is far from being a fixed charge. In some districts, through uneconomical operation, mismanagement and other causes, this has become a very serious burden, amounting in one instance to considerably over $3.00 per acre, per year, as compared with 30 to 60 cents per acre in fair sized districts having economical and well managed plants. There are a great many factors affecting the cost of operation which cause the operating cost to vary quite materially, even when the plant is well operated and maintained, such as size of district, kind of plant, exceptionally long periods of high water in river, exceptional heavy rainfall, rainfall not well distributed, seepage through leaky levees, and last but by no means least, spring water.

Experience along the Illinois and Upper Mississippi Rivers has demonstrated that spring water may easily add 100 per cent to the normal yearly pumping requirements. The unavoidable variations in operating cost from year to year make it too hazardous for the operation to be contracted on the lump sum basis, and the only plan which has been used to any extent in this region to increase the operating efficiency of the plants is to employ a supervising engineer, who makes tests at the plant under various operating conditions and determines the most economical pump speeds throughout the range of pumping head. He also keeps in touch with the plant by means of daily reports from the station engineer, containing data which, combined with the pump ratings, will give a complete plant test for each operating day. If anything goes wrong with the machinery in any way, it is thus discovered at once and corrected before any material amount of money is wasted in inefficient operation.

The matter of proper pump speed is of much greater importance in the Upper Mississippi Valley than in the Gulf Coast Region on account of the very much greater variation in pumping head, and consequent losses when the pumps are operated at the wrong speeds.

Another common cause for inefficiency is the partial obstruction of the waterways in the pumps or pipes by some foreign substance. Instances of this kind have been found where the obstruction had seriously reduced the pump capacity for a long period of time without being discovered and removed. The pump capacity is also oftentimes seriously reduced without the knowledge of the attendant by air pockets in the summit of the discharge pipes. The data contained in the daily operating reports would immediately disclose troubles of this kind to the supervising engineer.

Another valuable service rendered by the supervising engineer is in seeing to the proper maintenance of the plants and making the necessary repairs.

These plants always have a season during the summer and fall when they are completely shut down for long periods, and this affords an excellent opportunity for overhauling the plant, making any necessary repairs and putting all the equipment into first-class operating condition for the next pumping season.

Engineering supervision insures reliable pumping service, economical operation and proper plant maintenance, results which are of far more value to the drainage district than the cost of the service.

As previously stated, the experience in the region under discussion seems to indicate that engineering supervision of operation is fully as important to the continued success of these pumping plant projects as engineering design and supervision of construction, but it would appear that the general run of landowners and district officials must be educated considerably before engineering service will be employed in this connection to any great extent. The writer feels that the Drainage Investigation Division of the U. S. Department of Agriculture might very properly make this matter of pumping plant operation and maintenance the subject of a thorough investigation and bulletin.

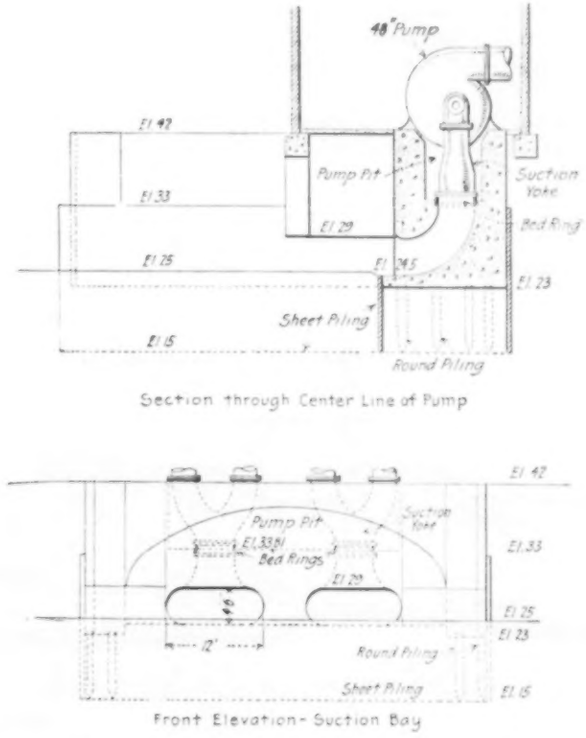

FIG. 2 FOUNDATION DETAILS OF THE PUMPING PLANT IN FIG. 1

MAXIMUM ULTIMATE ECONOMY OF THE WOOD SCREW PUMP POINTED OUT BY S. L. MENGE

S. L. MENGE (written). The function of a drainage-pumping station is to maintain the water level on its suction side lower than the water on its discharge side. When it has just ceased to do this, it becomes an obstruction instead of an asset, and its crucial test is its capacity to discharge more and more water with less and less power per unit discharged as the lift decreases and the necessity to pump therefore is most urgent. At the most crucial point, if the power and the pumping capacity are properly adjusted, one will be able to pump with the same power expenditure from three to five times as much water per applied brake horsepower with pumps having the characteristics of the new Wood screw pumps as with pumps having characteristics of the earlier type of pumps installed in New Orleans—or with the best design of centrifugal units.

The development of low-lift pumping machinery has necessarily been undertaken principally by the large pump manufacturers where competition involved simply the reliability,

economy and first cost of the pumps only, without consideration of the other essential features, which must be considered in the ultimate system.

The experience heretofore of the Sewerage and Water Board has been that during great storms, when lifts were much below the rated lifts, the older forms of pumps overloaded their motors and also overloaded the power stations, so that all pumping-station units could not be maintained in service. With the eleven additional screw pumps, which the Sewerage and Water Board proposes to install, and less than enough additional power to operate them at their rated lift, because the flow at rated lift can never supply all pumps, this condition will be reversed. The decreasing amount of power required to operate the new pumps as their lift decreases will more than compensate for the excess amount required by the old ones when their lift decreases and the necessity to pump is at its greatest.

According to a test conducted by Prof. W. H. P. Creighton, Dean of the Department of Technology, Tulane University,

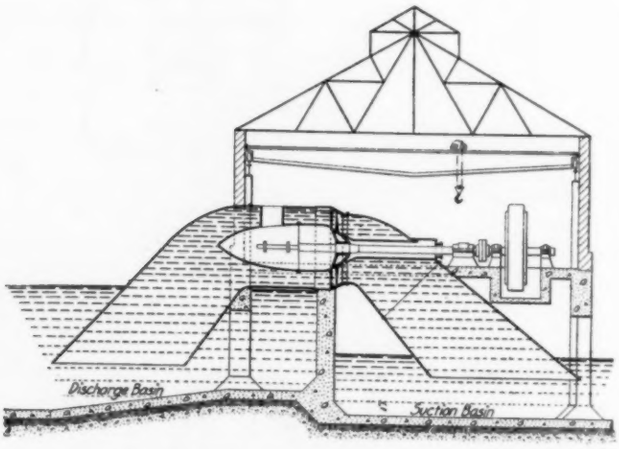

FIG. 3 SECTION THROUGH 12-FT. SCREW PUMP

New Orleans, the Wood screw pumps of the New Orleans Sewerage and Water Board give their best efficiency at 7 to 8-ft. lift, and show a better figure for 7½ ft. than the best of the Board's old centrifugal pumps at its best point, 11 ft. The advantages of accessibility, operation, first cost, etc., are, however, more than sufficient to dictate the use of the screw pump even if the power consumption characteristics were the same as those of the centrifugal.

Passing over the improvements which are apparent in the examination of the diagram of the comparative efficiency curves, it seems that the local benefit is best illustrated by comparing the cubic feet per second discharge per applied brake horsepower of the 76 r.p.m screw pump than for the other groups of pumps.

The best of these pumps, measured by this yardstick, adds only 50 per cent to its capacity per applied brake horsepower as its lift drops from its point of maximum efficiency, which is 11 ft., down to zero, while the new screw pump increases its capacity per applied brake horsepower 300 per cent from its lift for maximum efficiency at 7½ ft. down to zero.

In a system like that in New Orleans, operated electrically with power and pump capacity designed to give the required output under those low-lift conditions which require the greatest quantity of discharge, the power requirement to operate all units will be much less with screw than with centrifugal pumps. Since as the lift increases, the available flow approaching the stations decreases and fewer pumping units have to be operated, the power required to operate the pumps at a low lift will still suffice to operate enough units as the lift increases to take care of the decreasing flow. With pumps driven by power units capable of some speed variations, the characteristic of the screw pump is such that available power can be utilized at an increased speed at lifts far below the rated lift, without the serious sacrifice of efficiency which an increase of speed entails with centrifugal pumps.

Professor Creighton's test was made with a view towards determining the amount of water that one of the new 12-ft. Wood screw pumps could lift, and the efficiency of performance. The result shows that the pump raised 559 cu. ft. per sec. through a height of 5.6 ft. and 519.8 cu. ft. per sec. to 7.6 ft., the pump making between 75 and 76 r.p.m. and the efficiency varying between 76 and 80 per cent.

It should be noted that these pumps are not designed to fit a certain condition of lift, which may be more or less arbitrary and theoretical, but are designed to work with the maximum economy on widely varying lifts, such as actually obtain in service on practically every drainage problem.

The New Orleans units, with capacity of 500 to 600 cu. ft. per sec., can be advantageously installed in a space only slightly wider than the suction bells themselves (22 ft.) and depth of building of 50 ft. inside. They are particularly free from any vibration and, therefore, require little foundation mass. They operate at relatively high speeds, being particularly suited for direct connection to electric motors at constant speed. They are entirely self-oiling, no bearing coming in contact with the water or subject to grit and wear. A section of one of these pumps is given in Fig. 3.

ADDITIONAL DATA BY B. S. NELSON RELATING TO PIPE ENDS, SUCTION BASINS, ETC.

B. STANLEY NELSON (written). The author shows clearly the importance of enlarging the ends of the suction and discharge pipes to recover velocity head, because this head, unless converted to pressure head, and so recovered, represents a considerable portion of the total lift.

An important feature in the design of these expanding ends on the suction pipes is the angle of the plane of entrance with relation to the water line. The center line of the suction usually makes an angle of from 30 to 60 deg. with the water, and three types of ends naturally suggest themselves, as shown in Fig. 4, *A* being where the end is at right angles to the center line, *B* at right angles to the water and *C* parallel to the water.

The writer has had occasion to design and observe the behavior of a number of installations where one or other of the three forms of ends or modifications of them was used, and the conclusion is that type *C* is the best. Both *A* and *B* (particularly *A*) cause suckholes to be formed,—sometimes with a considerable depth of water over them, while with *C* it is possible to pump down to within a few inches of the end of the pipe. Suckholes are objectionable, as they admit air to the pump, and air in a centrifugal reduces both the capacity and efficiency.

The design of the discharge end of the pipes is not so important other than the ends should expand sufficiently to recover velocity head. In the typical drainage plant of this region, where the pumps discharge into an outfall canal close to the plant foundation, care must be taken to direct the flow

of water so as not to cause scouring of the canal bottom, and the design shown as *D*, Fig. 5, works very well. The flattened end, *D'*, is used on large pipes to reduce the depth at which the pipes must be set to maintain the siphon seal.

In his description of the test of the Louisiana Meadows oil engine driven plant, the author has touched on a feature of the typical drainage plant of this region, where pumps of large size with very short suction pipes are set in a dam across a canal, and that is the relation of the suction basin to the efficiency of the pumps.

At first thought, it would seem that if the suction basin were deep enough at the end of the pipe, it would need no further consideration, and that if there were some obstruction, the only effect would be to slightly increase the friction head due to restriction of area at entrance. It has been found, however, that where the suction basin is too shallow, or, if deep enough, through some irregularity of contour causes greater velocity of approach at one side than the other, or if there is a mud lump in front of the suction, the effect is not only to reduce the capacity, but also the efficiency of the pump. This is probably due to the fact that any disturbance at entrance goes on up through the suction into the pump impeller because the pipe is too short to allow the velocities across a section of the pipe to smooth out before reaching the pump. In the case of the Citrus plant, tests showed an increase in efficiency of about 8.5 per cent after dredging out the suction basin. The remedy is to give more thought to the design of the suction basin. This has usually been given but slight consideration, because it is the junction point of the dredging and machinery contractors, and each feels that it is the work of the other.

A very interesting and important feature of two of the plants mentioned, namely, the motor driven Citrus plant, and the oil engine driven Raceland plant, is the power characteristics of the pumps. The usual centrifugal pump power curve called for a great increase in power at heads much lower than normal working head, if the speed were kept constant. This presented no great difficulty in the case of the steam engine driven unit, for the steam engine is flexible, and the speed and cut-off could be varied to suit the head. But in the case of the motor driven plant it was, for obvious reasons, preferable to use a constant speed induction motor; it was also desirable to have the motors fully loaded at normal head, to get best motor efficiency. The problem was to design a pump which, when run at constant speed at all heads by a motor which would be fully loaded at normal head would not overload that motor at zero or intermediate heads. The pump builders met these conditions by using an impeller which is a combination of the centrifugal types—the pumps have a characteristic such that the ratios of the power input at 2, 4, 6, 8 and 10 feet to the power at normal head of 6 ft. are as follows: 0.93, 1.00, 1.00, 0.99 and 0.88.

In the case of the Raceland plant, the pump designer had additional problems to contend with in the characteristics of the oil engine. An oil engine should not be overloaded beyond about 10 per cent of its full load rating; its speed, for best results, is fixed, or nearly so; and in this size unit, this speed is considerably higher than the usual speed for a pump with 4 or 5-ft. lift. Direct connection was necessary because the initial cost of the oil engine precluded the use of a gear reduction such as was justifiable in the case of the motor driven plant. By the use of the combination impeller mentioned, the designer has built these pumps with a practically straight line power curve, the variation in horsepower at all working heads between zero and 7-ft. lift being about 5 per cent.

INDORSES MR. GREGORY'S PAPER AS SOURCE OF REFERENCE

A. M. SHAW (written). The author's careful exposition of the various types of pumps which have been used and the description of the conditions under which they have operated will do much toward reducing the labor and annoyances of engineers engaged in preparing plans for future installations for this kind of service.

Reference to this paper should suffice as an answer to many of the questions over which we are now wasting time and patience. It contains much valuable data which have hitherto been unavailable, and its net result will be a benefit to the profession and a still greater benefit to the public, as it will enable their designers, the engineers, to make use of past experience in the development of low-lift pumping machinery and to avoid the errors in design to which our attention has been called.

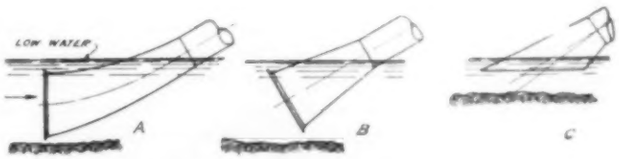

FIG. 4 TYPICAL SUCTION PIPE ENDS

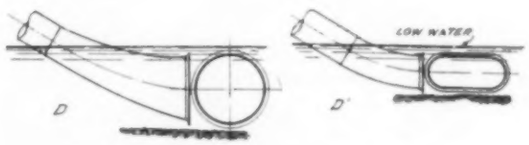

FIG. 5 TYPICAL DISCHARGE PIPE ENDS

DISCUSSION OF THE POSSIBILITIES OF OTHER TYPES OF PUMPING UNITS FOR THIS SERVICE

CHARLES C. TRUMP (written). There are new types of pumping engines already entering this field. The four-stroke cycle type of Humphrey pump, which uses internal combustion in direct contact with the liquid to be pumped, is hardly suitable for lifts under 15 ft., on which it depends for the compression which makes for efficiency of combustion. A two-stroke type now in process of development gives promise of working well on heads of 8 to 10 ft., but is somewhat high in first cost.

An entirely new type of pumping engine, known as the Tube pump, based in part on the principle of the Humphrey pump, has just been developed, and gives promise of working out, not only for large volumes with low lifts, but especially for small plants taking water from wells at lifts from 50 to 100 ft. or more for irrigation. This type of pumping engine may be driven by power cylinders using either internal combustion or steam.

As has already been discussed in recent papers before the Society, higher steam pressures present opportunities for improving the economies of steam power plants. Why should not such improvements be made as well in pumping engines?

It would seem as if marine engines adapted to high pressures would be suitable for driving screw pumps. Even steam turbines might be used; but an engine still better adapted to utilize the theoretical advantage of higher pressures is now available in the unaflow steam engine.

Designs of pumping engines on the unaflow principle, which uses a large ratio of expansion in one cylinder without condensation losses, and with few valves, have already been made by the Stumpf Una-Flow Engine Co. for many classes of service. A flywheel and crank engine with double acting plunger pump and steam cylinder with but two steam valves of the poppet type; a screw pump with vertical shaft and engine crank rotating in a horizontal plane; a marine type engine for high pressure steam (500-600 lb.) for driving a propeller in a tube for lifting water only 3 to 5 ft., and power cylinders of the unaflow type for Tube pumps have all been worked out and some of them are now in the shop. It should not be long, therefore, before some of these modern pumping engines are in the service this paper describes.

For generating high pressure steam economically in large units the Winslow Safety High Pressure boiler is now being built, the first unit of 500-h.p. capacity now being made for the City of Chicago. A small unit is being worked out with automatic control of water feed pump and fuel oil burner for use with a Tube pump of 800 gal. per min. capacity at 40 to 60-ft. lift, suitable for irrigation from artesian wells on individual farms without the need of skilled mechanical attendance. The first of these small units will probably be installed in the Nueces Valley in Texas in the near future, not far from the Gulf.

When some of the above pumping engines have proved their advance in economy, measured by the actual total cost of pumping under conditions of which I hope to have intimate knowledge, it would be a great pleasure to me to present before the Society for discussion one or more papers on this subject, with the hope that they may prove as interesting as this one by Professor Gregory.

S. T. WELLMAN also thought that the conditions described in the paper were ideal for the working of the Humphrey gas pump which has been developed in England and in which a mixture of gas and air is exploded in direct contact with the liquid to be pumped. In this type of pump heavy moving pistons are avoided and the only moving parts are the valves. The gas is made in a common gas producer and does not have to be purified. The economy of the pump is very high, while the cost is very low, as all the weighty parts are not finished at all.

W. B. GREGORY said that an installation of the Humphrey pump for irrigation work existed at Del Rio, Texas, but it did not yet appear that this type of pump is yet suited to the low lifts in drainage work. Most of the pumping in the Gulf Coast country for drainage and agriculture is done with a difference of level of from 3 to 5 ft., chiefly of the former. There are great differences to be overcome in applying the Humphrey pump to these low lifts. For high lifts he thought this pump had a future, particularly in parts of Texas and other parts of the country where lignite and cheap fuels from which producer gas may be made are available.

At present, some form of internal combustion engine seems to offer the best solution of the power problem for pumping plants in this section. Steam plants use much more fuel for an equal output of work and the boiler problems are often perplexing, especially in drainage plants where the feed water available is liable to cause trouble. Compound condensing Corliss engines have been used quite generally in irrigation and have also been used in some drainage plants. Superheated steam has been employed only in a few cases.

Designers of pumping plants must keep in mind the service for which the plant is intended. If the operation is to be continuous and the lift is through a considerable height it will pay to embody devices to save fuel and superheaters, economizers, expensive engines and all other refinements may be justified.

Irrigation plants are operated but 75 to 80 days per year. Drainage plants are often operated but 20 days per year. Due to the nature of the work the operation of both types of plant in a humid country, with occasional heavy rainfall, is intermittent and this is especially true of drainage plants. The fuel economies for these short runs must be balanced against the interest and depreciation of the more expensive plant. Furthermore, reliability of operation is of greater importance than economy and complications decrease reliability.

The rapid development of internal combustion engines, the varying price of fuel oil and the troubles incident to boilers and to steam plants generally all will have a bearing on the future pumping plants for irrigation and for drainage. Doubtless the future will witness changes that we may not today foresee.

At present pumps of the centrifugal and the screw types appear to hold undisputed sway in the field of low-lift pumping.

The influence of pressure on the explosibility of acetylene, as investigated by the U. S. Bureau of Mines, is given in the Bureau's Technical Paper No. 112, prepared by George A. Burrell and G. G. Oberfell from experiments made to determine the limits of complete propagation of flame in mixtures of acetylene and air.

Acetylene, not mixed with air, was enclosed in over mercury in a 100 c.c. glass vessel and its pressure slowly increased by means of a column of mercury until a maximum pressure of 5 atmospheres was obtained. There was no explosion. The experiment was twice repeated, and each time under a pressure of 5 atmospheres a mild explosion with the formation of much carbon resulted when a platinum coil in the gas was electrically brought to a white heat, while with the spark from an induction coil there was a violent explosion at 3 atmospheres.

When acetylene was mixed with air so as to form 10, 20, 30, 40, 50, 60, 70, 80 and 90 per cent acetylene mixtures, there was no explosion from compressing the mixtures to 1, 2, 3, 4, and 5 atmospheres. There was no use of any means of ignition such as an electric spark or a heated platinum coil.

The experiments showed that the smallest proportion of acetylene capable of propagating a flame in a mixture of acetylene and air was 2.53 per cent; the largest was about 73.

CORRESPONDENCE

CONTRIBUTIONS to the Correspondence Departments of The Journal by members are solicited by the Publication Committee. Contributions particularly welcomed are suggestions on Society Affairs, discussions of papers published in The Journal or brief articles of current interest to the membership.

THE GREAT DOMINION TELESCOPE

TO THE EDITOR:

Many attempts by the writer to picture mentally the distance to the nearest fixed star ended in a beggared imagination, until last year at the Spring Meeting of the A. S. M. E. he heard "Uncle John" Brashear measure the millions of miles with tons of iridescent spider web 1-5,000 inch in diameter.

Recently with 500 engineers and many other citizens he viewed the new 72-in. reflecting telescope temporarily mounted in the works of The Warner and Swasey Company in Cleveland. The story of the spider web came back with many other delightful recollections of that remarkable triumvirate, Warner, Swasey, and Brashear who share the distinction of manufacturing the world's greatest telescope. He felt that in

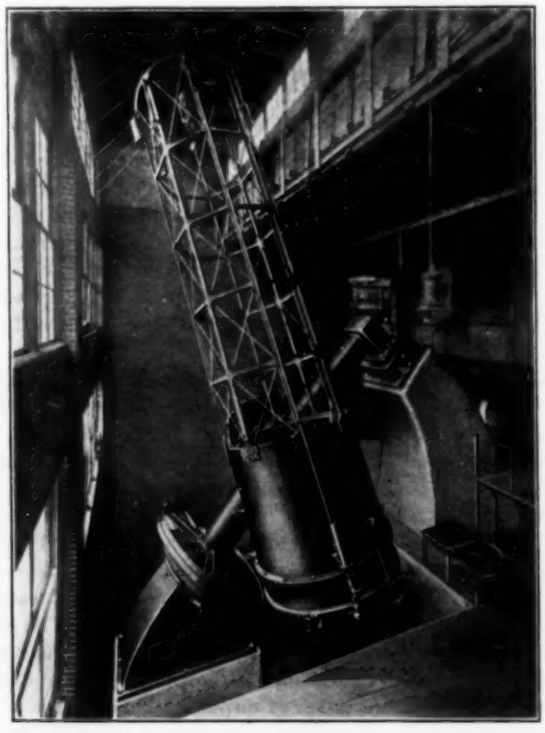

FIG. 1 72-IN. REFLECTING TELESCOPE IN WORKS OF THE WARNER & SWASEY COMPANY

the heart of the crowd was a desire to pay tribute to the engineers and scientist greater than to see the engine of science which may push back the celestial veil a few more million miles or reveal a few more million stars.

The telescope is for the Dominion Astronomical Observatory, Victoria, Canada. The principal mirror or speculum and all optical accessories are from the works of The John A. Brashear Company, of Pittsburgh. The reflecting surface of the 72-in. mirror is ground with such precision that it nowhere deviates from the parabolic theoretical curve more than two one-hundred-thousandths of an inch. The mirror is a casting of glass 12-in. thick at the edge and weighs two and a quarter tons, the great thickness being necessary to prevent all flexure. A full-sized model was on exhibition with the tube and may be seen near the right edge of the photograph, Fig. 1, as a white disk with a hole in the center, not unlike a huge grindstone.

All structural parts, including the revolving dome and observing bridge, were designed and constructed by The Warner and Swasey Company. A working model was made in the early stages of manufacture of cast aluminum at a cost of about $10,000, shown in Fig. 2.

FIG. 2 WORKING MODEL OF TELESCOPE

The telescope is of the equatorial-mounting type, supported at the north and south ends by bearings in a direction parallel to the earth's axis. The declination axis, to which the tube is attached at 90 deg. passes rectangularly through the central cubical portion of the polar axis. The instrument weighs 55 tons and will be mounted on reinforced concrete piers. It may be used in three forms, observations being made at the Prime focus, at the Newtonian focus, or at the Cassegrain focus. The principal work at the Cassegrain focus will be to analyze the light of the stars with spectograph. The resulting photographed spectra not only tell us the composition of the stars' atmosphere, but give by their flame length an accurate determination of their velocity toward or from us.

A precision driving-clock moves the telescope with great accuracy. With the Cassegrain focal length of 108 ft., the guiding speed of the star image at the focal plane is one three-hundredth inch per second.

The engineering and mechanical problems involved in designing and constructing a telescope of such proportions and accuracy are apparent only when an appreciation is had of the fineness of astronomical work. Accuracy in astronomy is illustrated by the study which accounts for the motion of the perigee of the moon within 1-300,000 per cent. Also by the fact that astronomers are searching for the cause of a monthly change of less than 1-1,000 of a second in the length of the month.

D. P. CLEVENS.

Cleveland, Ohio.

AMERICAN GAS CENTENARY

TO THE EDITOR:

The American Gas Centenary was celebrated in Baltimore on June 16 and 17 in an interesting and impressive manner. On June 17, 1816, the Mayor and City Council of Baltimore granted a franchise to The Gas Light Company of Baltimore to lay pipes for the distribution of gas in the highways of the city. In the following February, the General Assembly of Maryland granted a charter to The Gas Light Company of Baltimore. This pioneer charter devolved upon the present Consolidated Gas Electric Light and Power Company of Baltimore.

The Gas Light Company was the first gas company on this continent, its founding following only a few years after the incorporation of The Gas Light and Coke Company of London, the premier gas undertaking of the world. Since gas was first turned into the pipes in Baltimore, there has never been a failure in the supply.

To celebrate the introduction of gas lighting on this continent, as signalized by the founding of the first gas company in America, the Johns Hopkins University held a commemorative meeting on the evening of June 16 at McCoy Hall. President Frank J. Goodnow of the University presided, and the speakers were: Arthur Graham Glasgow, consulting engineer, of London, England; L. H. Baekeland, past-president of the American Electro-Chemical Society; Walton Clark, president of The Franklin Institute; J. E. Aldred, chairman of the board of directors of the Consolidated Gas Electric Light and Power Company of Baltimore; and Jansen Haines, president of the National Commercial Gas Association. President Goodnow read a message of congratulation on the celebration of the American Gas Centenary from The Gas Light and Coke Company of London, and announced the receipt of transcontinental telephone messages from John A. Britton, vice-president and general manager of the Pacific Gas and Electric Company, San Francisco, Cal., and E. C. Jones, chief engineer.

On the afternoon of June 16, a meeting was held of 841 employees of the Consolidated company whose length of service covered a period of more than five years. A number of these men had been associated with the company for more than half a century. Service badges, designating the length of service, were awarded to all of these employees, including forty-one men who have been retired and receive service annuities under the company's pension plan. It was announced that in addition to the present plan the company would institute a sick and death benefit system, under which all of its employees, after a few years of service, would be assured of a certain amount in the event of illness, and that payments would be made to their relatives in the event of their death. Under this plan, as well as under the pension plan, no contributions are made by employees.

On the morning of June 17, a tablet was erected on Peale's Museum, still standing in Baltimore, where, in 1816, Rembrandt Peale, artist, naturalist, and technologist, gave an exhibition of gas lighting, to witness which he charged an admission fee to those citizens of Baltimore who were interested in viewing the new light. Later, Rembrandt Peale in association with an architect, a newspaper man and a banker formed The Gas Light Company of Baltimore, and introduced the new illuminant to America. The tablet was presented by Charles M. Cohn, vice-president of the Consolidated company, and accepted by the officials of the city.

Following these exercises there was given, under the auspices of the Consolidated company, an educational and historical pageant. This consisted of a procession four miles in length, including 52 symbolic and allegorical floats, 2500 marchers, 200 motor vehicles, several hundred horses, and 10 bands. The purpose of the parade was to demonstrate graphically the development of the industry and the plant requirements made necessary by the obligation imposed upon a gas company to supply good and adequate service under all conditions. Thousands of people lined the streets to witness the procession, which was reviewed by the officials of the city and of the company.

C. C. THOMAS.

Baltimore, Md.

STANDARDS FOR ABBREVIATIONS

TO THE EDITOR:

In the April issue of The Journal on pages 319 and 320, appears a short article headed, "Conference on Abbreviations and Terminology." The following is quoted from this article: "Careful study was made of the abbreviations in general use, and complete agreement was reached concerning the abbreviations given in the list below. All abbreviations upon which unanimous agreement could not be had were omitted from consideration."

This is followed by a list of words, abbreviations and rules.

May I ask if one is to interpret the foregoing to mean that this list is hereafter to be the standard for The Journal? It shows some radical departures from the forms heretofore used in The Journal and Transactions, and there seems to be no good reason for the change.

In this connection attention should be called to the Preliminary Report of the Committee on Technical Nomenclature of the Society for the Promotion of Engineering Education, which appears in the June bulletin of that society. The purpose of the latter committee is to secure agreement throughout as wide a circle of technical men as possible, on the spelling, hyphenating and abbreviation of disputed technical terms.

The method followed by this committee of the S. P. E. E. was interesting. The various reports of the other national societies of engineering, that dealt with the questions of technical nomenclature, were compiled into one list of words. A number of inconsistencies were discovered, as would be expected. The list was then published in June, 1915, as a Preliminary Report. It was sent to teachers, writers and engineers all over the country with a request for criticisms and suggestions. All criticisms relating to a given word were written on a card assigned to that word, with the names of those making the criticisms. In addition, many lists of rules and suggestions were received by the committee from technical writers who were interested in technical nomenclature. The correspondence relating to this work was carried on for over

a year and the conclusions of the committee, as given in their report, should give a very fair idea of present tendencies among technical men in this country.

An effort was made to express the general tendency in a set of rules, although the variations were so great that no set of rules could be drawn that would give universal satisfaction. A great variation occurred in the use of the hyphen, and quite a tendency to omit hyphens was noted.

To attempt to quote from the report of this committee would carry one out of the bounds of a short letter, and a comparison of their recommendations with the practice of The American Society of Mechanical Engineers would be out of place until it is clear just what the practice of the latter society is at the present time.

JOHN T. FAIG.

Cincinnati, Ohio.

The list of abbreviations published in The Journal for April, to which Professor Faig refers, is the result of the work of a committee appointed by the National Electric Light Association to consider standards for "electrical measurements, values and terminology." When this committee met to consider the subject of abbreviations, invitations to attend were courteously extended to representatives of various engineering journals. In the case of the engineering societies, at least, these representatives appeared as individuals only and not as official appointees by these societies. The findings of the committee, therefore, are not applicable to the publications of The American Society of Mechanical Engineers except in so far as they are in accord with the standards already in use.

The standards now followed by our Society are based on a report issued in 1904 by a committee representing the four national societies of Civil, Mechanical, Mining and Electrical engineers. As a matter of convenience to those who contribute papers and discussions, the essential parts of this report are reprinted below. The chief divergence between this report and the list of the National Electric Light Association is in the writing of compound abbreviations. For example, in abbreviating kilowatt-hour our practice is kw-hr.; while that of the National Electric Light Association is kw.hr.

In a few particulars our present standard departs from the report of the four societies, notably in writing large numbers (see 12 below). The Mechanical, Mining and Electrical Engineers use commas to separate the periods of figures, while the Civil Engineers adhere to the report and use spaces without the commas. In some particulars this report needs revision to bring it into accord with present-day tendencies: as, for example, it is now quite usual to write horsepower as one word instead of as two words and to abbreviate it by hp. instead of by h.p.; and indicated horsepower by i.hp. instead of i.h.p. —EDITOR.

EXTRACT FROM REPORT OF THE FOUR SOCIETIES

1. Use abbreviations only after nouns denoting a definite quantity. Example: "The power plant has a capacity of 10 h.p.," not "10 horse power;" but, "The capacity of the plant, in horse power, is ten."

2. Do not abbreviate abstract or descriptive words. Example: "horizontal return tubular boilers," not "h.r.t. boilers."

3. Use lower-case characters for abbreviations. An exception to this rule may be made in the case of words spelled normally with a capital. Example: "B.t.u." and not "b.t.u." or "B.T.U." (British thermal unit); "U. S. gal." (United States gallon), "B. & S. gauge" (Brown and Sharpe gauge).

4. Use a period after each abbreviation. In a compound abbreviation, do not use a space after the period. Example: "i.h.p." and not "i. h. p." (indicated horse power).

5. Use a hyphen to connect abbreviations in cases where the words would take a hyphen if written out in full. When a hyphen is used, omit the period immediately preceding the hyphen. Example: "3 kw-hr." and not "3 kw. hr." (3 kilowatt-hours).

6. Use all abbreviations in the singular. Example: "17 lb." and not "17 lbs." (17 pounds), "14 in." and not "14 ins." (14 inches).

7. Never use "p." for "per," but spell out the word. Example: "100 ft-lb. per ton" (100 foot-pounds per ton); "60 miles per hr." (60 miles per hour).

8. Use decimals, as far as possible, in place of vulgar fractions. Example: "1.25 ft.," not "1¼ ft."

9. In general, spell out an adjective qualifying the name of a unit. Example: "boiler h.p." (boiler horse power). The exceptions to this rule are "i.h.p." (indicated horse power), "e.h.p." (electric horse power), "b.h.p." (brake horse power), "e.m.f." (electromotive force), "m.m.f." (magnetomotive force).

10. Use "Fig.," not "Figure." Example: "Fig. 3," and not "Figure 3."

11. In all decimal numbers having no units a cipher should be placed before the decimal point. Example: "0.32 lb.," not ".32 lb."

12. In the notation of large numbers, use "en" spaces instead of commas. Example: "1 520 125," not "1,520,125."

13. Use the word "by" instead of "x" in giving dimensions. Example: "8 by 12 in.," not "8 x 12 in."

14. Never use the characters (′) or (″) to indicate either feet and inches; or minutes and seconds as periods of time.

The following forms are given as illustrations of these rules, and are recommended to be used:

NAME	ABBREVIATION
Inches	in.
Feet	ft.
Yards	yd.
Miles	spell out
Pounds	lb.
Grains	gr.
Tons	spell out
Gallons	gal.
Metres	m.
Millimetres	mm.
Centimetres	cm.
Kilometres	km.
Kilogrammes	kg.
Grammes	g.
Milligrammes	mg.
Kilogramme-metres	kg-m.
Metre-kilogrammes	m-kg.
Seconds	sec.
Minutes	min.
Hours	hr.
Linear	lin.
Square	sq.
Cubic	cu.
Per	spell out
Fahrenheit	fahr.
Centigrade	cent.
Per cent	% or per cent
Volts	spell out
Ohms	spell out
Watts	spell out
Kilowatts	kw.
Kilowatt-hours	kw-hr.
Watt-hours	watt-hr.
Amperes	spell out
Brake horse power	b.h.p.
Electric horse power	e.h.p.
Indicated horse power	i.h.p.
British thermal units	B.t.u.
Gramme-calories	g-cal.
Kilogramme-calories	kg-cal.
Magnetomotive force	m.m.f.
Electromotive force	e.m.f.
Revolutions per minute	rev. per min.
Circular mils	cir. mils.
Miles per hour per second	miles per hr. per sec.
Candle-power	c-p.
Watts per candle-power	watts per c-p.
Mean effective pressure	spell out
High pressure cylinder	spell out
Diameter	spell out

COMMENTS ON RECLAMATION PLANT

TO THE EDITOR:

The writer has found the paper by Mr. Noble on the reclamation plant in the Sacramento Valley[1] of great interest

[1] THE JOURNAL, May, 1916.

because of its points of similarity with drainage problems of the Gulf Coast country and especially because of its points of dissimilarity. The heads are much greater than in Louisiana and Texas and are more in line with those found in the reclamation projects of the Mississippi Valley.

With a normal head of 29 ft., perhaps one may leave out refinements in the discharge pipes. While the suction pipes seem to have been carefully designed, the discharge pipes as shown in Figs. 7 and 9 are not so easy to understand. In Fig. 8 there is shown a condition where the water level is at least 6 ft. below the bottom of the discharge pipe. In this part of the country it is usual to design the piping for drainage pumping plants so that it forms, with the pump, a siphon; also to enlarge the discharge end until the final velocity is low. In this way the pumps, besides overcoming entrance losses, friction and discharge losses have only to elevate the water through a height equivalent to the difference of level of suction and discharge basins and the energy thrown away at the discharge is small.

When each of the units is pumping 175 sec-ft. the velocity in the 50-in. discharge pipes is 12.85 ft. per sec. and the velocity head about 2.56 ft., while at the final discharge, which is 78 in. in diameter, the velocity is 10.5 ft. per sec., corresponding to a velocity head of 1.72 ft. It would be interesting to know what the mean head pumped against amounts to or what it was assumed to be in designing the plant. Since for lower heads than 29 ft. the discharge velocities would be greater than those given above and the losses in the discharge pipe, whether running the pumps singly or in pairs, must be a fairly large per cent of the total head. It would seem to be worth while to have carried each discharge pipe down to such a level that the end would be water sealed except possibly at extreme low water. It would also seem desirable to have large end areas and consequently low discharge velocity.

Each discharge pipe is provided with a 50-in. gate valve. Could not these expensive valves have been eliminated by carrying the discharge pipes over the levees instead of through them? The writer would like to ask Mr. Noble whether the advantages of a straight pipe with a gate valve are sufficient to justify the added expense.

It is evident that conditions are quite different in California from those in the South, also that many details necessary to a thorough understanding of the problem are omitted. For these reasons the above questions are raised in order to clarify the problem.

W. B. GREGORY.

New Orleans, La.

ORIGIN OF UNIFLOW ENGINE

To the Editor:

I noticed a statement in the April issue of The Journal that a paper was presented before the Minnesota Section of the Society, consisting "mainly of a description, the origin of the Uniflow engine in Germany, together with its manufacture, etc." I presume that the author of the paper, in giving his talk, claimed the German origin of this principle on the basis of the recent work by Prof. Johann Stumpf, of Charlottenburg, on the development of the Uniflow engine. It is generally conceded that the uniflow principle was invented in England by L. J. Todd, who took out his patent for this invention in 1886. Apparently Todd's invention was never put into practice, but on December 10, 1895, the two brothers Cleveland took out an American patent for a uniflow cylinder, which was first put on a traction engine and later on locomotive No. 59 of the Canadian Intercolonial Railway.

Some time since, the writer had occasion to look into the history of the uniflow engine, and found an early American patent showing, although not claiming, the uniflow principle. The date of this patent was November 12, 1867, and the patent was granted John M. Hirlinger for an Improvement in Steam Engines (U. S. Patent No. 70,841).

Hirlinger's invention is illustrated in Fig. 3. It consists of a steam cylinder, *A*, with both ends permanently closed. Upon one side is formed a V-shaped channel, in which works a similarly-shaped slide, *H*. *G* is a bolt which passes through *H* and has its inner end secured fast in the piston *B*. The steam chest has within it a cut-off valve, *D*, which has on its

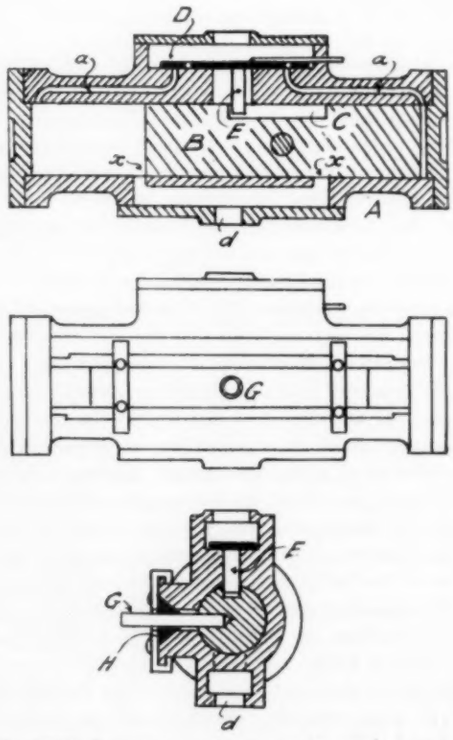

FIG. 3 1867 INVENTION SHOWING UNIFORM PRINCIPLE

underside a pin, *E*, extending into the cylinder into the recess, *C*, in the piston. The valve *D* has two steam openings communicating with the steam ways, *a,a*, which admit steam to the cylinder. The playing of the piston in the cylinder causes the valve to move so as to admit steam at each end. This arrangement of valve with its pin and the piston with its recess dispenses with the necessity of having cams and rods for working the valve. *The steam, when exhausted, escapes through the openings x,x, and d, at the under side of the cylinder.*

As stated above, the inventor did not claim the embodiment of the uniflow principle, from which we must assume that the idea of exhausting the steam from a cylinder through ports at or near the center of its length, and of controlling the opening of the exhaust ports by the ends of the piston, was not patentable (had already been utilized) in 1867, or was not regarded as of sufficient merit to warrant protection by a patent.

WILLIAM E. BULLOCK.

Jamaica, N. Y.

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SOCIETY AFFAIRS

A Record of the Current Activities of the Society, its Members, Council, Committees, Sections and Student Branches; and an Account of Professional Affairs of Interest to the Membership

THE total number of applications for membership listed in The Journal this month is 236. This represents an increase of 124 over last month, and brings the total number of new applications since the beginning of the current fiscal year up to 913.

The main activities of the Sections and Student Branches are now suspended for the season. The year has been a record one in number of professional and social meetings held and variety and value of topics discussed. The work of the Sections for the year is summarized below.

The plans of the Committee on Meetings for the Annual Meeting to be held in New York, December 5 to 8, 1916, are beginning to assume a definite form. The Committee has now practically completed arrangements for a session on Valuation.

The Publication Committee met jointly with the Executive Committee during the month just closed and voted unanimously to include in the volume of Condensed Catalogues now in course of preparation a classified index of manufacturers.

The Publication Committee has approved the contents of Volume 37 of Transactions, and the volume is now being printed and will be issued at an early date.

The President has appointed E. M. Herr, *Chairman*, Henry Hess, S. M. Vauclain, L. D. Burlingame and F. A. Halsey as a Committee on the Metric System to ascertain the views of the membership regarding the adoption of this system as a standard in this country and to represent the Society in conferences with other societies upon this question.

The name of the Committee on Flanges for Hydraulic Work has been changed to Committee on Standard Flanges and Pipe Fittings, and the committee enlarged as follows: Henry G. Stott, *Chairman*, A. R. Baylis, Stanley Flagg, Jr., E. M. Herr, A. M. Houser, Julian Kennedy, E. A. Stillman, A. M. White, meetings and will appear in the Transactions.

Upon the request of the Organization Committee of the City of New York on the celebration of the bringing of water from the Catskill Mountains into New York, the following committee was appointed to represent the Society on the Mayor's Citizens' Committee: The President, Henry R. Towne, Past-President, who originated the suggestion for the celebration, John R. Freeman, Past President and Consulting Engineer for the City of New York during the inception and construction of the city's additional water supply, Fred J. Miller and Charles Whiting Baker.

E. G. Spillsbury has been appointed a trustee of the United Engineering Society.

Fred J. Miller has been appointed on the Committee on Engineering Education.

WHAT THE SECTIONS HAVE DONE THIS YEAR

The spirit of coöperation among engineers has influenced to a remarkable degree the activities of the Sections during the season just closed. Local problems of affiliation of Sections with other societies have been successfully worked out, and in practically all of the fifteen centers of established Sections joint meetings have now become the custom.

Meetings in Atlanta have been held in conjunction with the affiliated technical societies in that city. Coöperation among the engineering societies of Boston has been followed from the inception of the Section six years ago. In Buffalo the Section has coöperated with the Buffalo Engineering Society. The meetings in Cincinnati have generally been joint meetings with the Engineers' Club, as also in Milwaukee and St. Louis. A recent meeting of the Los Angeles Section was held with all the technical societies in that city, the meeting being under the auspices of our Section. The Minnesota Section has held meetings in three cities, St. Paul, Minneapolis and Duluth. In Philadelphia joint meetings have been held with the Engineers' Club and The Franklin Institute. The meetings in Providence have been those of the Providence Association of Mechanical Engineers, now the Providence Engineering Society, affiliated with our Society. In New York there has been coöperation with other organizations and a number of joint meetings have been held, also in New Haven.

It is very gratifying to note that in this matter of bringing the local societies together, our Sections have in many cases taken the initiative. The Society has no jealousies, and its fundamental purpose is Service to the engineering profession.

MEETINGS AND PAPERS

In all, one hundred and six meetings have been held this season and all have been reported in The Journal. Nineteen of the papers presented locally have been published in The Journal in full and fourteen others will be published in due course. Eight papers originally presented at Section meetings during the season have been subsequently delivered at general meetings and will appear in the Transactions.

This plan is a definite purpose of the Meetings Committee, approved by the Council, to enhance the dignity of the Section meetings and develop the interest. On account of the necessarily crowded program of the Annual Meetings of the Society, for which there is no relief in sight, it is obvious that a more extended discussion can be obtained by presentation of papers before Section meetings.

THE SECTIONS AND THE SOCIETY

The same coöperative spirit which has brought the Sections into close contact with other local organizations is now mani-

fest in the relations between the Sections themselves and the Sections and the Society proper, and also between the National Engineering Societies.

The first Conference of Sections was held at the 1915 Spring Meeting, and was such a success that a second Conference was arranged at the Annual Meeting in New York, December, 1915. A representative from each of the fourteen Sections then established was present, and also delegates from the Providence Engineering Society and from several industrial centers where members of the Society were interested in the formation of Sections. Three business meetings were held and the delegates had opportunity to discuss matters with the officers and members of the Council.

The Nominating Committee for officers of the Society was this year chosen by the Sections at the request of President Jacobus. The report of this Committee appears elsewhere in this issue of The Journal.

Two very fine examples of coöperation between the Sections and the parent organization were the receptions accorded the Society at San Francisco and Birmingham, the former on the occasion of the September, 1915, meeting of the Society and the latter when the officers and members were en route to the Spring Meeting in New Orleans.

GOVERNMENT OF SECTIONS

The plan for having all the Sections elect their officers at a uniform time and by a uniform method, either by vote at an open meeting or by letter ballot, has now been consummated, and the officers for all the Sections for the ensuing year will assume their duties on July 1. A list of the new officers appears elsewhere in this issue.

There has been evidenced a necessity for a Code which would tend to put the activities of all the Sections upon a more uniform basis, and the Committee on Sections has been engaged in formulating such a Code. The Committee is hopeful of securing the coöperation of all the national engineering societies in putting their respective Sections upon the same general basis.

NEW SECTIONS

A new Section has just been established in Detroit. The first meeting of this Section will be held next September and the policy will be to coöperate completely with the Detroit Engineering Society and the Michigan Society of Engineers.

As noted in the last issue of The Journal, plans are also now under consideration for the establishment of a Section in Baltimore.

THE SECTIONS AND VISITS OF OFFICERS

Probably no greater series of receptions have ever been accorded the officer of any society than those which were extended to Past-President Brashear upon the occasions of his visits to San Francisco, St. Louis, Milwaukee, Washington and the many other cities where he made addresses during his term of office. His plea for the development of the "human factor in engineering" was as well received as it was timely, and he brought to the members of those Sections which were fortunate enough to arrange to have him visit them, a better understanding of the meaning of "coöperation among engineers."

During the current year President Jacobus has similarly visited the Sections at Philadelphia, Chicago, Milwaukee and St. Paul to consult the members upon matters of import to the Society, and he plans to extend these visits in the forthcoming season to include all Sections by the end of the year if possible. The Secretary has also attended meetings of the New Haven, Philadelphia, Providence, Buffalo, Boston and Birmingham Sections.

REPORTS OF ACTIVITIES FROM CHAIRMEN

Below are given reports from the Chairmen of the Sections which have now come to hand. Other reports are expected and will be published in the next issue of The Journal.

EXPERIENCES OF BIRMINGHAM, OUR NEWEST WORKING SECTION

TO THE SECRETARY:

The Birmingham Section was organized in November 1915, and we have had a meeting each month since that time. Most of these meetings were given to the details of complete organization and preparing for the entertaining of the visiting engineers who stopped over to visit us on their way to the Spring Convention at New Orleans in April.

During the coming year we do not expect to hold meetings each month but we will have a meeting at least once every two months. I think that where there is no organization of all the engineers in a district forming a general engineering association of the members of National Societies it is asking too much of the members of a local organization to meet every month and at the same time try to have some specially written papers to present at each meeting.

All of our meetings have been well attended and were of the nature of a dinner at a moderate cost preceding the regular business meeting. The members were given their option of coming to the dinner or reporting later for the business meeting, and we are happy to state that all were on hand for the dinner part of the meeting. We held our meetings at the different clubs and hotel parlors in the city, not having any regular designated place of meeting.

I believe that a meeting which combines the social with the business is the best kind of a meeting for all concerned and especially so for those Sections not located in the big cities. As a rule the members composing the smaller Sections are men who are busy all day at their respective work and do but little writing and are entirely out of practice in writing for publication, and therefore hesitate about writing a paper for presentation to the Section and afterward for publication in The Journal. For sections composed of membership of this make-up the social side appeals very strongly as it affords another way of getting better acquainted with one's fellow engineers.

I believe that all Sections should make it a practice to invite, from time to time, the more prominent business men and the heads of manufacturing establishments in their district, to their meetings. We need to develop a better and more intimate acquaintance among those who require the advice of engineers.

I think that the plan that the Society has for loaning out special moving picture films is a good one and it is one that the Sections ought to take advantage of. I might suggest, however, that it would be much better in the case of some films, if the makers would send a copy of the lecture with them.

Another thing which I think is vitally needed by the Sections is each Section should be visited at least once each year by the President of the Society. In fact it would not be a bad idea if the President and Secretary would arrange to leave

New York, either in the early Fall or early Spring and visit each Section, allowing the Sections time enough in advance to properly prepare a meeting suitable for the occasion. I believe that the cause of engineering would be given a great boost and certainly the members of Sections would feel a greater pride in their membership and be spurred to put forth greater efforts in behalf of the Society and engineering.

Our Section anticipated with much pleasure the stop-over here by the Society on its way to the Spring meeting in New Orleans, and we would have been particularly happy had President Jacobus been able then to visit the newest Section and the greatest industrial district of the South. I think that the Council should consider making some arrangement to give all Sections the pleasure of a visit by the President every year.

Yours very truly,

R. E. BRAKEMAN,
Chairman, Birmingham Section.

THE BUFFALO SECTION AND THE ENGINEERING SOCIETY THERE

TO THE SECRETARY:

During the last year we had only one distinct local meeting of the members of the Society, and this meeting was a lunch meeting at noon. We had only twelve members present at this meeting, which was called for the purpose of determination regarding chairmanship of the Section, and the motion was carried that the chairman of the Buffalo Section would be the President of the Engineering Society of Buffalo, providing he was a member of the Society. The election is to take effect at the annual election of the Engineering Society of Buffalo.

The Engineering Society of Buffalo did not hold an annual meeting this season for the reason that at a regular meeting, it was decided to continue the present officers for another year. Therefore, John Younger is President for the coming year of the Engineering Society of Buffalo.

Very truly yours,

D. BELL,
Chairman, Buffalo Section.

CINCINNATI HAS ITS MOST SUCCESSFUL YEAR. LOOKS FORWARD TO SPRING MEETING, 1917

TO THE SECRETARY:

The year just past has been the most successful in the life of the Cincinnati Section, since its organization in May 1912. Each year there has been an increase in interest and in attendance at the meetings. The present year, however, has been characterized by more ambitious programs than in the past, particularly the March program, which began at 2:30 in the afternoon and continued until 10 o'clock at night. Four papers were presented on this occasion. These four papers were of wide variety and yet all were of general interest. The afternoon session of the meeting on March 16 was an experiment and a rather slender attendance was anticipated. To the surprise of the members of the Section the afternoon session was very well attended and the session proved to be one of the most enjoyable of the year. The March meeting was notable in that it attracted more persons from out of town than was the usual experience.

Meetings of the Cincinnati Section are held as joint meetings with the Engineers' Club of Cincinnati. The meetings are held in the handsome rooms of the Literary Club of Cincinnati, which are on the first floor of a building located very close to the center of the city and within easy access of all parts of the city. About four times a year the Cincinnati Section takes over the program and arranges the entire meeting. This happened to be the case in March and also happens to be the case in June, when Major P. S. Bond of the Engineer Corps of the United States Army will address a joint meeting on Preparedness from the Point of View of the Engineer. This is a topic of unquestioned timeliness, and will probably result in a definite program looking toward preparedness on the part of engineers in this vicinity under the auspices of the Cincinnati Section, Am.Soc.M.E.

The proposal that the 1917 Spring meeting of the Society be held in Cincinnati was greeted with great enthusiasm by the members of the Section, and it was through their earnest coöperation that the meeting was secured for the Queen City.

Of the fact that Cincinnati is a very excellent place for a Spring Meeting there can be no doubt. Its nearness to the center of population of the country; the wide variety of the industries which it has fostered; and its resources from an artistic and musical point of view all combine to make it of interest both to technical men and their relatives and friends. Cincinnati is within easy distance of the famous Blue Grass region of Kentucky, and there is no doubt that an opportunity for a visit will be afforded to such as are interested in this region at the time of the Spring Meeting.

Naturally the activities of the Society for the coming year will focus about the Spring Meeting of the Society. The formation of committees to handle the preliminary work which is necessary to make any convention a success and the working out of a program for the outside features of the meeting will require much time and thought. There is no doubt that the meeting will end in a blaze of enthusiasm as far as the Cincinnati members are concerned, and that the membership of the Society will be greatly increased in this immediate vicinity.

Very truly yours,

JOHN T. FAIG,
Secretary, Cincinnati Section.

LUNCH MEETINGS SUCCESSFUL AT LOS ANGELES

TO THE SECRETARY:

Owing to our limited membership, we have not deemed it wise to attempt to hold a large number of professional sessions. During the past year, in addition to four regular meetings, we inaugurated the weekly luncheon meeting which has met with remarkable success. These meetings were started solely for the purpose of bringing the members together once a week for a "getting acquainted" purpose. We later began with a system of ten-minute talks which increased the attendance materially and added value to the meetings. These talks are very informal and all features that would tend to place them in the speech-making category have been barred. The members have responded ably and willingly at these luncheon meetings and the subjects discussed have been principally in the line of local work on which the members are engaged. Many of these little talks have brought out original data and reports on investigations which might never have been heard of otherwise.

These luncheon meetings have served another purpose of value equal to those previously mentioned, and that is, the bringing of new men into the Society. We aim to take up topics of local interest, and that attracts always. It is our intention to broaden these meetings, and with this in view a Committee from the Local Section A.I.E.E. is to meet with us shortly to discuss the joining of the two sections at these luncheon meetings. As we have no Engineers' Club in our city, we feel that this system will lead up to such an organization.

Next to the success of the meetings above mentioned, comes our work in connection with bringing together into closer relationship, the several engineering organizations of the city. During the past year we held two joint meetings, the first one for the entertainment of General George Goethals, and the second held on the evening of June 1, devoted to the subject of preparedness. This led up to our being part of the big Preparedness Parade held here on June 14, marching as the Joint Technical Societies of Los Angeles. We had over 400 technical men in line. Such affairs as these aid in cementing close ties among the engineering organizations, and our Section has been particularly active in this work. During the next year we hope to see much progress in this affiliation movement.

Our experience indicates that we must combine some social time with the technical part of the meetings. Our regular professional sessions are well attended as they are made attractive by social features. For example, one of our best meetings during the past year was an inspection of the Mt. Wilson Solar Observatory Laboratory, Pasadena, California, where the famous 100-in. reflector is being constructed, with a banquet in the evening followed by a lecture on the engineering and constructional features of this wonderful instrument and the building which is to house it, by F. G. Pease, Member of the Society, and engineer and astronomer for the Mt. Wilson Solar Observatory.

We take this occasion to suggest that the Increase of Membership Committee be consolidated with the Committee on Sections. The work is so closely allied that there should be no dividing line. Let the Executive Committee of each Section recommend the member to serve as the Chairman of the Increase of Membership Committee for that particular Section, he to be a member of the Executive Committee and to report direct to the Chairman of the Section who in turn reports to headquarters.

Yours very truly,

W. W. SMITH,
Chairman, Los Angeles Section.

OUR BIGGEST SECTION HAS A PROGRESSIVE WINTER AND IS CONTINUING DURING SUMMER

TO THE SECRETARY:

Meetings of the local members of the Society in New York have been conducted after a different plan from those in other cities, until comparatively recently. The committee having them in charge was known as the Committee on Local Meetings in New York, and New York was not referred to or thought of as a Section like the Sections in other cities. Now, however, the practice has been changed to conform with other parts of the country, and the committee of five formerly appointed or self-perpetuating is being elected by popular vote, the change having just been made with the elections of last month.

The principal difference between our work during the six months previous as compared with the preceding year is that the committee of five was augmented by the appointment of three sub-committees, one of Entertainment, one on Excursions, and one on Acquaintanceship, of upwards of ten members each, who make it their special duty to look after these particular features of the section work. The results so far have been very gratifying; and whereas nothing special was done for either entertainment or excursion matters prior to this time, both of these committees, as well as the Acquaintanceship Committee, have been doing splendid work, and we feel that the interest in and attendance upon all of the activities of the Section have been considerably stimulated by this means.

Our technical meetings since the first of the year have been, we believe, up to a par with the high standard which had been prevailing prior to that time, and the attendance at the meetings has been very gratifying, being usually over four hundred.

We have made a special effort to have joint meetings with other societies wherever opportunity afforded, and two of them in the last few months have been of that order.

Briefly, our program since the first of the year has been as follows:

January 11, Standardization of Power Plant Operating Costs, Walter N. Polakov. This meeting brought out a very lively discussion of the paper and thus was of considerable value to those who attended.

February 8, Ways of Presenting Data for Executive Purposes, speaker T. Russell Robinson, Statistical Engineer for W. S. Barstow & Co., Inc., New York City. This was a very profitable if not spectacular meeting.

March 14, Joint Meeting with the Illuminating Engineering Society, to consider the Factory Lighting Code formulated by that Society. Prof. C. E. Clewell presented the Code for the Illuminating Engineers and L. P. Alford discussed it from the standpoint of the Mechanical Engineers.

Another Joint Meeting was that held April 21, with the Metropolitan Section of the Society of Automobile Engineers, at which the subject of the power plant of the automobile was discussed, particularly with reference to the four-cylinder motor. Two papers were presented, one by F. E. Watts, Chief Engineer of the Hupp Motor Car Corp., and one by Finley Robertson Porter, of the Finley Robertson Porter Co., Port Jefferson, L. I.

The meeting of May 9 considered a paper on the Report upon Efficiency Tests of a 30,000 kw. Cross-Compound Steam Turbine, by Henry G. Stott and W. S. Finlay, Jr., of the Interborough Rapid Transit Co.

It has been the practice to have an informal dinner before the meeting, usually at a cost of about 75 cents a plate, and these dinners have been very well attended.

The Entertainment Committee arranged for two events which have already transpired, one an informal dinner at the Machinery Club, March 29, to which ladies were invited, and which was followed by dancing. A very representative turnout was secured.

The latest event was the participation, with the Brooklyn Engineers' Club, the Municipal Engineers' Club, and the Harvard Engineering Society, in a moonlight sail on the Hudson River. About a hundred members of our Section participated in this trip on June 15.

The Excursion Committee expects to maintain its activities throughout the Summer, holding technical excursions, usually on Saturday afternoons, about every two weeks. So far, the only two held have been those to the Essex Power Station of the Public Service Company of New Jersey and the High-Pressure Fire Service Station at Gansevoort and West Streets. Another event contemplated is a theatre party some time in July, with a midnight supper and dance to follow, arrangements for which will be completed if enough signify an interest.

Our Excursion Bulletin, second issue, is an indication of how things are moving with this Section, even after the suspension of the technical affairs during the summer months. Plans for the Fall are already quite well under way, and more subjects have been suggested than could possibly be covered in several years.

A joint meeting of all of the committee members, held a short time ago, was very fruitful in getting out suggestions for future meetings, and this Section can give it as its conviction from experience that getting a large number of people to work is great for enthusiasm and the bringing out of suggestions for new things. As an entertainment feature in the Fall we are planning a smoker, for we believe that the social side of the engineer must not be neglected.

We do not like the idea of attempting to mix the social and technical too intimately, and we believe that on our regular meeting nights the subjects should be more or less technical, but that some extra meetings as far as our appropriation will allow, can be indulged in with benefit where there is no attempt to do other than amuse and entertain. The excursions so far have been practically altogether technical, but we are hoping that there may be some element of the social mixed in with them at times. They always afford a splendid opportunity for extending acquaintance, which is one of their big advantages.

Our Section is also very strong for joint meetings, and we believe the intermingling of engineers of somewhat different interests is broadening to all, and conducive to that ultimate goal which so many of us hope to attain, when engineers of all persuasions will be more united, all to the greater effectiveness of their influence on engineering questions affecting the general public welfare.

Very truly yours,

H. R. COBLEIGH,
Chairman, New York Section.

EXCURSION BULLETIN

NEW YORK SECTION

The American Society of Mechanical Engineers
29 West 39th St., New York

VOL. 1, No. 2. JUNE 1916 ALL WELCOME

Technical Excursion June 10, 1916, 3:00 p. m.
Moonlight Sail and Dance June 15, 1916, 7:20 p. m.

TECHNICAL EXCURSION

June 10, 1916

The members of the New York Section and their friends are invited to visit the Gansevoort High Pressure Fire Service Station on Saturday afternoon, June 10, 1916, at three o'clock (3:00 p.m.).

This interesting municipal installation is located at Gansevoort and West Streets, and can most readily be reached by taking the 14th Street Crosstown Car to 10th Avenue, and walking South four blocks.

MOONLIGHT SAIL AND DANCE

June 15, 1916

All the local members of The American Society of Mechanical Engineers and their friends are invited to participate in a moonlight sail and dance on the Steamer "Mandalay" on the evening of June 15.

By co-operating with the Brooklyn Engineers' Club, the Municipal Engineers of the City of New York and The Harvard Engineering Society, the entire boat (licensed to carry 3000 persons) has been chartered for the exclusive use of the engineering societies and as only 750 tickets will be sold there will be no crowding. The trip itself is a delightful one and as an unusual opportunity will be afforded to meet engineers of various interests it is certain that those who can avail themselves of this occasion will be well repaid.

The Steamer "Mandalay" will leave the Battery Landing, Thursday evening, June 15 at 7:20 and will return to the same place about midnight.

Tickets are $1.00 each and may be obtained from

JAMES W. NELSON, 82 Broome St., New York.
(Telephone, Orchard 2075)

to whose order checks should be drawn.

The allotment to our Society is only 250 tickets which will be issued in the order the requests are received, accompanied by cash or check.

THEATRE PARTY, MIDNIGHT SUPPER AND DANCE

The Committee has under advisement the holding of a Theatre Party with a Mid-night Supper and Dance, and would like to know whether or not the New York membership and their friends would support such a venture. It is proposed to take the party some time during the first half of July to the Winter Garden furnishing the best seats in the house ($3.00), afterwards convey the party to Shanley's where a table d'hote supper ($1.50) will be served with dancing in a private room, at a total cost not to exceed $2 50 per person. All those who would like to avail themselves of this unusual opportunity should send their names and addresses to EDWARD VAN WINKLE, 90 West Street, New York City. Should a sufficient number signify their intention of attending, the date will be fixed and a subsequent notice will be sent out. Forward your acceptance not later than June 10th.

(TEAR OFF)

_____ 1916.

MR. JAMES W. NELSON
82 Broome St., New York.

Dear Sir:-

Enclosed please find { Cash / Check } for $ . . . . . for which please send me _____ tickets for the Moonlight Sail and Dance to be held June 15, 1916.

Name _____

Address _____

(TEAR OFF)

_____ 1916.

MR. EDWARD VAN WINKLE
90 West St., New York.

Dear Sir:-

I wish to participate in the Theatre Party, Mid-night Supper and Dance to be held in July.

I will desire tickets for _____ persons at not to exceed $2.50 each to cover the entire expense and upon notice that the party will be held, will forward my remittance.

Name _____

Address _____

(REPRODUCTION OF THE 2ND EXCURSION BULLETIN ISSUED BY THE NEW YORK SECTION WHICH HAS EXTENDED ITS ACTIVITIES INTO THE SUMMER)

PHILADELPHIA HAS CONSUMMATED PLANS FOR COMPLETE COÖPERATION

TO THE SECRETARY:

In arranging the program for the Philadelphia Section for the year 1915-1916, special attention was given to securing subjects of general rather than specifically technical interest in order to stimulate enthusiastic support from the entire local membership. With this in mind J. A. Steinmetz, President of the Pennsylvania Aero Club, and a member of the Society, was called upon to present the first paper of the year on Aero Warfare and Some Devices Terrestrial and Submarine.

At the second meeting held on November 23, 1915, W. P. Barba, General Manager of the Midvale Steel Company, presented a paper on Industrial Safety. The Section was gratified to hear that Mr. Barba's paper was subsequently chosen for presentation at the annual meeting.

Developments of the Pumping Engine was the subject of a paper presented at the meeting of the Section on February 3 by Prof. A. M. Greene, Jr., of Rensselaer Polytechnic Institute, with whom many members of the Section are well acquainted on account of his former Philadelphia associations. This meeting was a joint one with The Franklin Institute and was held at the Institute. Before the meeting Professor Greene was entertained at dinner by the officers of the two organizations.

On April 10 a joint meeting with the American Institute of Electrical Engineers was held at the Engineers' Club. The general subject was Some Prime Movers Now Under Development. Three papers were presented on live subjects,—The Uniflow Engine; Future Possibilities of the Large Steam Turbine Generator in Electric Generating Service, and the Diesel Engine.

At the meeting of April 25, the Section was honored by the presence of Dr. D. S. Jacobus, President of the Society, who gave the members of the Section a much clearer insight into the affairs and problems of the Society. The President's talk was preceded by an informal dinner which was well attended by the members.

The last meeting of the season was held Tuesday evening, May 23, at the Engineers' Club. A paper was presented by Lieut-Com. H. C. Dinger, U. S. N., on Efficiency of Propulsive Machinery and Late Developments in Naval Engineering. Besides reviewing in an able manner the progress of engineering in the Navy, the speaker made an appeal to the engineering profession to coöperate with the Navy in placing our country in a better state of preparedness. In expressing appreciation of the spirit in which this appeal was made, the Secretary of the Society, Calvin W. Rice, spoke with special earnestness and promised the fullest coöperation from the members of the Society. Following the paper the Chairman-elect of the Section, E. B. Carter, who also has the honor of being President of the Engineers' Club for the present year, was presented and expressed his belief that one of the principal obligations of the Philadelphia Section is to make itself especially useful in assisting to get the entire engineering profession in Philadelphia and vicinity to center around the Engineers' Club.

As an earnest of this coöperative spirit, the retiring local committee gave a dinner at the University Club, prior to the meeting, to which invitations had been extended to the officers of the local technical organizations. Mr. Rice was also present. The occasion was very enjoyable and presaged a successful forthcoming season.

The spirit of coöperation, which has taken such a positive hold among the various engineering organizations of Philadelphia, is bringing the engineers of this community closer and closer together and the question of the exact field for the sections of the various national societies is likely to change as this coöperation progresses.

At the present time, there seems to be a feeling that the more distinctly technical subjects should be discussed by the local sections of the various engineering bodies and that subjects of general engineering interest should be taken up by the Engineers' Club of Philadelphia which is the main body about which the various local sections of the national societies center.

The future of these local sections depends also upon the final plan for the development of the Engineers' Club. This Club now has a membership of approximately 2500 and with the affiliated societies the total membership in Philadelphia aggregates 3800, not including The Franklin Institute. Within the next year the development plans of the Engineers' Club will undoubtedly be definitely determined and the relation of the Section of The American Society of Mechanical Engineers and other similar affiliated societies to this development problem will unquestionably be of interest to all other Sections of the Society.

Very truly yours,

R. H. FERNALD,
Chairman, Philadelphia Section.

SAN FRANCISCO HAS PROBLEMS AND APPARENTLY WAYS OF MEETING THEM

TO THE SECRETARY:

Last year we had with us many delegates from our National Scientific Bodies and one International in scope. With the many meetings of these conventions and the almost innumerable subjects upon which papers and discussions were prepared, we thought it best to postpone all meetings of our local section A.S.M.E. until early in 1916. However, the Committee met from time to time and made plans for this year's program. As a unit the Committee decided that the quality of papers presented, four in all, in order to be of the highest standard, demanded that the authors should be given a greater length of time for preparation. The subjects therefore were all selected early in the year, and the authors except one, decided upon.

Last year we discussed the advisability of having joint meetings of the A.I.E.E., A.I.M.E., A.S.C.E., A.C.S. and A.S.M.E. The first meeting this year was held June 2 with a large attendance representing each Society. *Short* talks were given by representatives from each branch, corn-cob pipes and tobacco were distributed gratis, and a half-hour talk given on the electrification of part of the system of one of our large railroads. Later we had beer, crackers, etc., unpretentiously and wholly informally. The Committee in charge were so well pleased with the attendance that other meetings of similar character are planned for the year. We feel that attendance will be larger in the future, as several said they had no idea what a good time they would have.

We therefore plan for this year four formal papers with discussions, four or more smokers, and a number, as yet undetermined, of joint meetings of the five Societies. We have also arranged to notify the Secretaries of other Societies when we are to hold meetings and they are to post notice and invitation to attend on their bulletin board. Similar notice to be posted on Bulletin Board of the Engineers' Club.

The Engineers' Club is the logical headquarters for our Section as well as for the other engineering societies and we feel that the club members should belong to the various societies and that the society members should belong to the Club. The human element in Engineers collectively is just as strong as in members of other professions, but we think the individual does not know this; it is to be our endeavor to prove it.

We feel that a larger percentage of our members should attend the meetings. Just how to get them there we have not as yet discovered. We have frankly asked them what they want in the line of papers or entertainment. So far we have not received any definite recommendations. The Committee has decided, however, that the quality of a paper must be excellent, the subject one of interest to the majority and ample time allowed for preparation. It is our hope to have the papers printed and distributed before presentation in the future to the end that discussions shall represent more mature analysis and deliberation.

It is proposed to induce the Engineers' Club to purchase a moving picture and stereopticon outfit, the branches of the various societies to pay, say, $10 for the use of the machine at each meeting until cost has been absorbed. After that no charge to be made for the use of the outfit. It so happens that one of our Committee is a director of the Club and this, to us at least is a very attractive arrangement, of advantage to the Club and to our Section in many ways.

The Club has also arranged for the various local branch committees to meet at the Club quarters if they so desire without expense.

It is also thought advisable to offer inducements to the younger men to attend our meetings. The presentation of technical papers is as a whole probably of less interest to them than purely social gatherings. This is our reason for planning to hold alternate formal and informal meetings. This also, with other reasons, has led us to meet after dinner rather than before. It is planned during the coming winter to have informal meetings monthly on Saturday afternoon preceded by a buffet lunch without cost to those who attend.

Very truly yours,

F. W. GAY,
Chairman, San Francisco Section.

REPORT OF NOMINATING COMMITTEE

The Secretary announces the receipt of the report of the Nominating Committee charged by President Jacobus with the duty of nominating candidates for the forthcoming vacancies in elective offices. It will be recalled that the Nominating Committee was this year appointed by the President from five groups of the different geographic sections of the Society with the object of securing the greatest possible democracy. The Committee consisted of Walter B. Snow, Chairman, representing the Boston, New Haven and Worcester Sections; H. M. Montgomery, representing the Chicago, Milwaukee and Minnesota Sections; E. H. Ohle, representing the Atlanta, Birmingham, St. Louis and Cincinnati Sections; J. T. Whittlesey, representing the San Francisco and Los Angeles Sections, and D. Robert Yarnall, representing the New York, Philadelphia and Buffalo Sections. The report from the Chairman follows:

TO THE SECRETARY:

Dear Sir: Acting for the Nominating Committee, which you advised upon February 24, 1916 of their appointment by the President, I have the honor to submit the following report.

As the result of several meetings at New Orleans in April, and subsequent personal interviews on the part of individual members, the following names of nominees for the various elective offices next falling vacant under the Constitution, together with the written consent of each nominee, are herewith presented:

For President, for one year:

IRA N. HOLLIS, Worcester, Mass.

For Vice-Presidents, for two years:

CHARLES H. BENJAMIN, Lafayette, Ind.
ARTHUR M. GREENE, JR., Troy, N. Y.
CHARLES T. PLUNKETT, Adams, Mass.

For Managers, for three years:

ROBERT H. FERNALD, Philadelphia, Pa.
WILLIAM B. GREGORY, New Orleans, La.
C. R. WEYMOUTH, Berkeley, Cal.

For Treasurer:

WILLIAM H. WILEY, New York, N. Y.

Respectfully submitted,

FOR THE COMMITTEE,
(*Signed*) WALTER B. SNOW, *Chairman.*

ACKNOWLEDGMENT

Attention has been called to the unfortunate omission from the report of the Committee on Standardization of Flanges as published in Volume 36 of the Transactions of the Society of the name of the National Association of Master Steam and Hot Water Fitters. Acknowledgment is hereby made by the Committee on Standardization of Flanges to the Association for its generous support and work in the preparation of this report, and the name of the Association will appear hereafter on any publication of the report by the Society.

It will be found that the dimensions published by the Master Steam and Hot Water Fitters Association under the title of 1915 U. S. Standard are identical with the dimensions in the American Standard published by the Society.

INDUSTRIAL PREPAREDNESS

The War Department has detailed five officers of the Regular Army to duty with the United States Naval Consulting Board, to assist the Committee on Industrial Preparedness, of which Howard E. Coffin, Mem.Am.Soc.M.E., is Chairman, in mobilizing for war purposes the various munitions-making and other industries of the country. These officers are Colonel Abiel L. Smith, of the Quartermaster Corps; Major William D. Connor, of the General Staff; Captain Douglas MacArthur, of the Corps of Engineers and the General Staff; Captain Richard H. Somers, of the Ordnance Department, and Captain Charles S. Wallace, of the Signal Corps.

The following statement, announcing the detail of the army officers to aid Mr. Coffin and the committee, was issued on June 23 from the office of the Board in the Engineering Societies' Building:

"In view of present conditions, the Committee on Industrial Preparedness of the Naval Consulting Board of the United States is exerting all possible pressure to complete its great industrial survey, and is rushing its work to the limit.

"Supervising Director W. S. Gifford announces that the War Department, for the purpose of helping rush to completion the nation-wide inventory, has just assigned five officers of the regular service to duty at the committee's headquarters in the Engineering Societies' Building, New York. Mr. Gifford states that these officers will immediately begin to classify the returns now coming in from the committee's army of engineers in the field, particularly with reference to items of army supplies.

"The Government is especially desirous of knowing in a specific way how the manufacturers of America can transform their plants to producing munitions of war and the thousand and one things needed in an unending stream in a modern conflict. Particular attention is being given to the adaptability of plants along this line in the Southwestern States. It goes without saying that the Government will gain enormous benefit by receiving at this time the vast data being collected by the Committee on Industrial Preparedness, and Secretary of War Baker is co-operating with Chairman Howard E. Coffin in every way.

"The business men of the country continue to respond in the most patriotic manner to the committee's survey, and the returns from the industrial inventory are pouring in from every part of the Union."

Through the efforts of the members of the national engineering societies acting as State Directors on the industrial census, the names of more than 100,000 American manufacturing concerns willing to aid in every possible way in the manufacture of munitions and supplies of all kinds that will be needed in the event of war have been secured.

ROLL OF HONOR

The Society is compiling a list of all members enlisted or contemplating enlistment in the National Guard, the Regular Army, the Navy, or in any other capacity in the services of the country; and in order that this list may be as complete as possible, members connected with military or naval units are requested to send to the Secretary, The American Society of Mechanical Engineers, 29 West 39th St., New York, N. Y., particulars of their rank and the unit in which they are serving or expect to serve.

As, obviously, on account of their being in the service of the country, some men may not see this notice, every member of the Society who knows of any other member now engaged or about to be engaged in the service of the country in any capacity is invited to notify the Secretary.

DEATH OF DR. CORTHELL

It is with profound regret that we record the death of Dr. Elmer Lawrence Corthell, president of the American Society of Civil Engineers.

Dr. Corthell's professional activities covered a remarkably wide range—bridges, railways, terminals, river channel rectification, harbors, canals, waterworks, and protection of sea coasts, and earned for him a brilliant reputation in three continents.

He also participated actively in the affairs of the engineer, particularly as they related to matters of public policy. He was always prominent at international congresses of engineers, where his European and South American experience made him an invaluable member of committees.

To a greater extent, perhaps, than any engineer living today did he come into close contact with important men and projects of national magnitude, and his death leaves a void in the profession which only time can fill.

Dr. Corthell was a member, in many cases honorary or life member, of nearly sixty engineering and scientific organizations. Before his death he not only gave his library of several thousand volumes to Brown University, but provided for the proceedings of these societies to be sent in perpetuity to Brown University.

As early as 1893, the time of the International Engineering Congress, of which he was general chairman, and perhaps even before that time, Dr. Corthell had the desire "to unite in closer social and professional relations the engineers of the world." This was stated in a paper he prepared in 1895.

Later he was active in the organization of the International Association of Engineers which, with headquarters in Brussels, is realizing Dr. Corthell's dream of twenty years ago.

With the closer coöperation of the engineering societies in America, in which he was active, we hope still further to consummate his world-wide ambition of the engineering profession.

CCÖPERATION AT LOS ANGELES

It is exceedingly gratifying to note the hard work being done by the Sections to coördinate their activities with those of other local organizations. Two months ago we were able to report a remarkable meeting of the New Haven Section in which seven other organizations participated, and now we are advised that the Los Angeles Section held on June 1

a joint dinner-meeting with the local branches of the American Society of Civil Engineers, the American Institute of Mining Engineers, the American Institute of Electrical Engineers, the American Chemical Society and the Engineers and Architects Association. As in the case at New Haven, the joint meeting was the result of the activity of the Chairman of our Section.

The subject of the meeting was Industrial Preparedness, and there was a general discussion on the plans of the U. S. Naval Consulting Board and of its Associate Members to secure, through the Board's Committee on Industrial Preparedness, an accurate industrial inventory of this country's manufacturing and producing resources for the purpose of national defense.

Mr. Arthur Benton presided and Dean George A. Damon, of the Throop College of Technology, acted as toastmaster. The speakers of the evening were: Rev. George N. Davidson; Earle Remington, President of the Aero Club of Los Angeles; Capt. Charles T. Leeds, U.S.A. (retired); Major George B. Pillsbury, U.S.A., in charge of fortifications, San Pedro; George W. Dickie, Vice-President Am.Soc.M.E., and Willis H. Booth, Vice-President of the Security National Bank.

VICE-PRESIDENT DICKIE DISCUSSES PREPAREDNESS

The subject of Mr. Dickie's address was Industrial Preparedness. Mr. Dickie outlined the Naval Consulting Board's plan for taking the industrial census, and expressed his confidence that the members of the organizations now being called upon to render service in connection with this inventory would welcome the opportunity to coöperate in this important and purely defensive work undertaken for the protection of our country.

He drew upon the European War to emphasize what it meant to a nation to be prepared and what unprepared. He said that at the outbreak of the war, Great Britain was notoriously short of munitions, whereas to-day she had an abundance. The story of the industrial transformation that made such a change possible is one of the most remarkable chapters in the romance of motor-driven automatic and semi-automatic lathes. He gave the following unique results of urging every manufacturer in that country to utilize his equipment for the service of the army and navy.

INTERESTING EXAMPLES FROM EUROPE

A concern engaged before the war in preparing infant's food is now delivering thousands of plugs for shell. A well-known manufacturer of baking machinery has become an expert contractor for 6-in. high explosive shells. A jewelery house is devoting itself exclusively to the manufacture of periscopes. Among the producers of finished shell are found candle-makers, flour mills, tobacco manufacturers and makers of sporting goods.

In some cases the adaptation of old plants and their tool equipment to the making of munitions has been incredibly rapid. Thus the government prevailed on a firm making textile machinery to take an order for field-kitchens. The firm was one of the largest and best known in Great Britain and employed some 8000 hands; so it made over one of its shops to furnish field-kitchens. Their men, very likely, had never seen one of these until they went to work, but in an amazingly short time they completed the delivery of what quartermasters described as the finest field-kitchens they had ever had. Thus encouraged, the Minister of Munitions prevailed on the company to begin the manufacture of 4.5 shell. The whole plant was readjusted and is now reckoned one of the most reliable of all government contractors. The credit for such results belongs not only to the Minister of Munitions and the manufacturers, but in a large measure to the workmen and especially to the women volunteers.

There have been mustered into the machine shops of Great Britain over 200,000 women, who are largely engaged on the most intricate processes of shell making. One young dressmaker who volunteered was put at a machine which was supposed, in the hands of a good workman, to turn out thirty shell parts an hour. This woman's regular output is now seventy-five an hour. Another expert is a young typist who had five brothers in the army; one was killed, another was disabled, and the others still bear their part in the fighting. Not to be behindhand in patriotism, this girl deserted the office for the factory, and is now one of the most expert machinists in the empire. Her passionate hatred of the enemy makes her disobey every order to slow down.

Besides heroic women, many men have left unnecessary professions for the munitions plants. Several members of the House of Lords are regular machinists. In one city every lawyer and court official goes on Saturday afternoon to a factory and works steadily, with just enough time off for sleep, until the sessions are resumed on Monday. The effect of this industrial mobilization on the British Army and Navy may in a sense be measured; things which are now possible were impossible a year ago.

WHAT THIS COUNTRY WOULD NEED

For present day war needs, he questioned how many of us realize that to produce the gages and jigs necessary to manufacture the 200,000 shells daily required by an adequate artillery force in action would swamp the facilities of the three largest plants in this country now making these articles—swamp them from now until the year 1921, and that preliminary item alone would cost $18,000,000. In the event of even a medium-sized war with a first-class power we would need 120 times our present number of machines fitted and instantly ready for munition manufacture. More than that we would need three men sweating in a factory for every soldier or sailor at the front. If we were to plan for an army of a million men, and that is not big compared with the armies now at war in Europe, we must also plan another army of three million men to supply the necessary things required by the million in the field.

To-day the Frankford arsenal is the only one we have equipped for the making of field gun ammunition; if it worked night and day for 365 days it would be able to supply just about enough shells for a single day's shooting by an army of a million men so that, in the event of war, to supply ammunition for field guns alone for such an army we would need 365 duplicates of the Frankford arsenal.

Years ago Germany knew how many shells and other mechanical things that were necessary for war, and how many parts each little machine shop in the country could make, and she gave these shops actual practice in making them, so that on the afternoon of July 28, 1914, two hours after the declaration of war, every concern in Germany that could make munitions was working full capacity on such work. Great Britain got ready in about a year.

Of course, merely taking an inventory of our manufacturing plants to determine their possibilities in case of war would in itself be useless. These plants must be furnished in advance with all necessary designs and the jigs and gages for the manufacture of such war material as they are fitted for, and they must be regularly inspected to insure their ability to shift without loss of time from the products of peace to the products of war.

Then our railroads must be ready for the job that war

would bring them, should the misfortune of war overtake us. Our 250,000 miles of steel highway would become the very backbone of our power to stand. Yet how little are we prepared to care for the extraordinary quantity of traffic that would be headed for strategic points in that emergency. He would not advocate for our country's railroad tracts to be dedicated to the promotion of war, but he did believe that if our Government would begin to regard our railroads as a link, the most important link in the chain of preparedness, they would soon be able to respond with increased facilities to care for extraordinary needs the Government might have for their service.

BOILER CODE COMMITTEE

The Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Anyone desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, Mr. C. W. Obert, 29 West 39th Street, New York City.

Since the issue of the first edition of the Code, the demand for copies has averaged almost 1000 a month.

DEDICATION OF NEW TECHNOLOGY BUILDINGS

The dedication of "New Technology" at Cambridge, Mass., on June 12-14 marked an epoch in the history of technical education in this country and in the fullest sense was a golden anniversary for the Massachusetts Institute of Technology and the many alumni and friends of this great institution.

In 1846 William Barton Rogers, the founder of the Institute, enunciated a "Plan for a Polytechnic School in Boston," which comprised the study of physical laws and scientific principles as the basis for the processes of the industries,—a radical conception in those early days of empiricalism. Exactly fifty years ago, in 1866, his life's desire was fulfilled in the erection on Boylston Street, Boston, of the stately "Rogers Building," the first home of the Institute and ever since its main or administration building.

This, and the other buildings occupied by the school in different parts of the city, have long been inadequate, their arrangements inconvenient, and with all there has been no dormitory, no gymnasium, and but little opportunity to care for the social and physical welfare of the students.

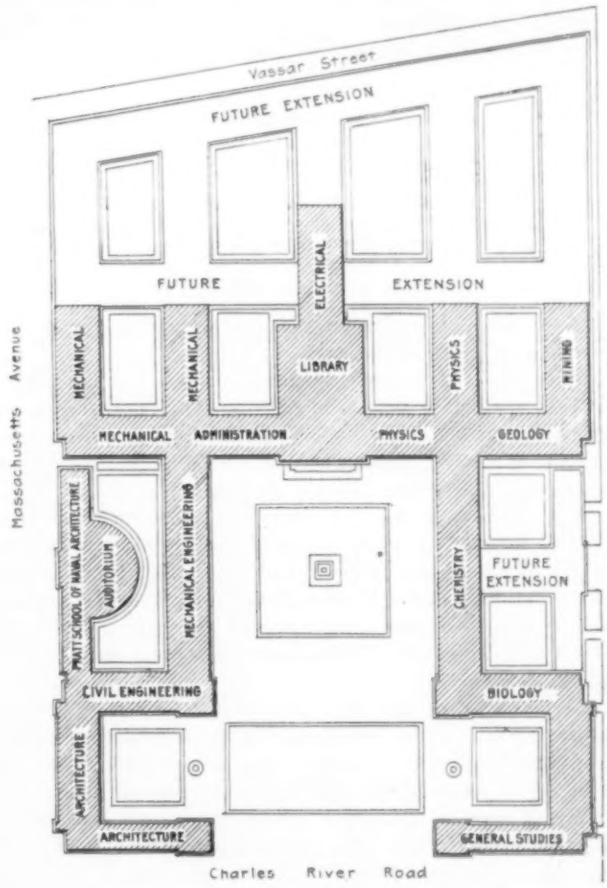
Now all this is to be changed and in accordance with a plan so complete and on a scale so great as to partake of an element of grandeur in its final realization. Through the gifts of alumni and friends, and of an unknown donor, the "mysterious Mr. Smith," it has been made possible to erect on a tract of land bordering on the Charles River, Cambridge, a $7,000,000 group of buildings, of which the main or educational building is practically completed and the others are in process of construction.

At the exercises in June a formal farewell was paid to the old Rogers Building which has meant so much in the life of the Institute, and with elaborate ceremonies and a wonderful pageant the new buildings across the river were dedicated to the continuation of the work of education and enlightenment.

After a long study of the problem by engineers, notably by John R. Freeman, Mem.Am.Soc.M.E., and finally by the architect, Wm. W. Bosworth, it was decided to adopt a single building type of construction to meet the educational needs, instead of the usual group of detached buildings.

The library, which must be so important a factor in any system of education, has been made the central feature of this building, with a great dome nearly two hundred feet high. The various wings are grouped about a great court, the immense proportions of which may be indicated by an illustrative statement which seems appropriate under present conditions, that it would easily harbour ten of the largest battleships of the U. S. Navy.

The building is of concrete, faced with limestone, and probably is the largest monolithic structure in the world. Its fundamental principle of construction is a system of bays of uniform size throughout, which constitute units for growth



FLOOR PLAN OF NEW EDUCATIONAL BUILDING OF MASSACHUSETTS INSTITUTE OF TECHNOLOGY

and future extensions. The floors are supported entirely by the exterior walls, independent of the dividing partitions, and the rooms for the different departments can be changed in size at will, in any multiple of the single-bay unit, to suit conditions of development. It is the sectional book case idea applied to architectural planning.

Like the stacks of a book case, also, the building may be added to by erecting extensions or wings, as shown in the plan view herewith. As it now stands it will accommodate 2000 students and there can be future extensions for as many more.

The classic type of architecture has been followed and into it has been moulded with rare skill an adaptation to modern requirements in the way of window space and overhead light-

Courtesy of Stone & Webster.

NEW EDUCATIONAL BUILDING OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

There are 18 acres of floor space, and in its construction were used 365 carloads of stone, 5,000,000 brick, and 80,000 bags of cement. The dome is 180 ft. high and the great court would hold the Boston Public Library, with room for a city street on either side. The power house has 2000 h.p. steam capacity, and there are 2½ acres of drafting rooms and large laboratories for the various departments, including a hydraulic laboratory, with 800 ft. of canals and pumps of 22,000 gal. per min. capacity, and an aëro-dynamic laboratory, with 4-ft. blowing tunnel of 40 miles an hour capacity.

ing and other utility features such as are usually found only in the most recent factory type of building.

Five thousand Technology men, hundreds of Technology women, and other thousands of interested friends gathered from far and near for the dedication exercises. The jubilee started in lively fashion with the arrival of the New York contingent, 700 strong, by boat on Monday morning.

The exercises on that day comprised the impressive "farewell to Rogers" at which James P. Munroe, long associated in the affairs of the Institute, was the orator; the laying of the cornerstone of the Walker Memorial; and in the interims the various luncheons, inspection of the new buildings, a water festival on the Charles River basin; and class dinners in the evening.

No incident of the day was more impressive than the gathering late in the evening of the thousands of graduates and undergraduates in front of the Rogers Building to bid final adieu, when the flag was lowered for the last time.

Mr. Munroe in his address likened the Rogers Building to a Westminster Abbey for Technology and pointed out the many influences which have contributed to build up its power and influence over its men. He spoke of the splendid "Spirit of Technology" which had developed there and expressed the belief that it had the vigor to grow to far greater proportions and still higher fame when transplanted to the Charles River site.

"Into the Rogers Building," said Mr. Munroe, "we have builded the multiform labors of 100 great leaders and thousands of their neophytes, all seeking the one enduring thing in life, the truth; all scorning to reach their ends by any other road than that of hard work; all ambitious, but for the general good; all fired with the desire to contribute something toward the bettering of human conditions and the uplifting of the world; all striving for the greatest of human possessions, character."

"But the soul of it, the legacy of Presidents Rogers, Runkle and Walker and all the rest, we take with us, not in memory, but in actuality, and we believe that in conveying it across the Charles we are leading it to opportunities, far more full of promise than even those which today we so proudly and gratefully commemorate."

On Tuesday throngs of the visitors went by boat to Nantasket to witness the class stunts and in the evening was the wonderful pageant in the great court of the new educational building.

Starting with the formal and impressive transfer of the charter and seal of the Institute from the old to the new temples of learning, by the State Barge "Bucentaur" which proceeded across the Charles under the glare of searchlights and fireworks; and continuing with the several episodes of the majestic "Masque of Power," it constituted an elaborate and brilliant spectacle of surpassing beauty.

The first episode of the Masque of Power represented Chaos; the second the Dance of the Elements,—air, water, fire, etc. Then came primitive man and his efforts at mastery of the elements portrayed. But man alone could not triumph over nature and Will and Wisdom appeared and led historic groups of the ages,—Egypt, Greece, Rome, and the various Centuries in succession, each contributing its share of progress under growing enlightenment, the whole making a most impressive grouping under the colored lights in the grand court.

Then out of darkness came Greed, Selfishness and War, and a return to Chaos; but there was a rift in the clouds, a ray of light appeared, and Righteousness, Will and Wisdom swept irresistibly forward, breaking the war, overcoming the elements, and finally reigning supreme.

In the afternoon were the formal exercises of dedication with addresses by Governor McCall of Massachusetts, President Lowell of Harvard, Henry Cabot Lodge and President Maclaurin of the Institute. There were in attendance the representatives of many educational institutions and a very large audience in the great Court of the New Technology. President Maclaurin fittingly announced the purpose of Technology as that of "strengthening American industry at its base by fixing it firmly on the solid rock of science."

The concluding event was the banquet in the evening, with a combined attendance of 4000 diners and guests. The feature of the occasion was telephonic communication for every one

present and for 2000 or more other Technology men in 33 other cities, with the speakers at the banquet and with those who spoke in the other connected cities. Undoubtedly this was the climax of the many similar transcontinental demonstrations which have been arranged through the courtesy of the officials of the American Telephone and Telegraph Company.

At exactly 9 o'clock Eastern time, the connections were made for a period of two hours and without interruption to the regular service of the several cities. In rapid succession was the roll call of the cities, with prompt response from each. There followed telephonic addresses by President Stone of the Alumni Association, President Maclaurin, J. J. Carty, chief engineer of the American Telephone and Telegraph Company, and others; after which there were exchanges of greetings between Dr. Alexander Graham Bell, Orville Wright, Thomas A. Edison, Theodore N. Vail and various speakers in Boston and other cities. It was a remarkable demonstration of the marvelous advance of telephonic science from the barely audible message of the inventor, Alexander Graham Bell, to this great national convocation, made possible by the vision and organizing skill of Theodore N. Vail and the engineering triumphs of J. J. Carty, his predecessors and associates.

APPLICATIONS FOR MEMBERSHIP

TO BE VOTED ON AFTER AUGUST 10, 1916

Members are requested to scrutinize with care the following list of candidates who have filed applications for membership in the Society. These are subdivided according to the grades for which their ages qualify them and not with regard to professional qualifications, i. e., the ages of those under the first heading place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, and those in the third under Junior grade only. Applications for change of grading are also posted.

The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into Membership by advising the Secretary promptly of any one whose eligibility for membership is in any way questioned. All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote. Unless objection is made to any of the candidates posted, by July 10, 1916, and providing satisfactory replies have been received from the required number of references, these candidates will be balloted upon by the Council. Those elected to membership will be notified by the Secretary about September 15, 1916.

NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

ADELMAN, ARTHUR, Draftsman,
Ordnance Office, War Dept., Washington, D. C.

BALDWIN, HARRY G., Supt.,
S. K. F. Ball Bearing Co., Hartford, Conn.

BELCHER, PAUL W., Junior Mech. Engr.,
U. S. Engr. Dept., War Dept., San Francisco, Cal.

BENJAMIN, LOUIS S., Ch. Engr.,
Atlantic Sugar Refineries, Ltd., St. John, N. B., Canada

BENTLEY, LOUIS L., Superintendent,
Armstrong Cork Co., Beaver Falls, Pa.

BERGMAN, LARS H., Engineer,
Midvale Steel Co., Philadelphia, Pa.

BIGGS, WILLIAM E., Master Mechanic and Chief Engineer,
Aluminum Co. of America, Maryville, Tenn.

BILGER, HENRY E., Supt. of Tools and Gauges,
The Baldwin Locomotive Works, Eddystone, Pa.

BISBEE, D. A., Asst. Supt.,
South Brooklyn Mch. Corp., Brooklyn, N. Y.

BLISS, ALBERT L., Asst. Supt.,
Baxter Stove Co., Mansfield, Ohio

BODINSON, LARS W., Chief Engr.,
The American Well Works, Aurora, Ill.

BRISTOL, CHARLES F., Genl. Supt.,
Armstrong Whitworth of Canada, Ltd., Montreal, Canada

BROWER, CLARENCE L., Chief Engr.,
U. S. Metals Refining Co., Chrome, N. J.

BROWN, DAVIS, Supt. Engrg. Dept.,
The American Clay Mchy. Co., Bucyrus, Ohio

BUNKER, WALTER D., Genl. Supt.,
Judson Manufacturing Co., Emeryville, Oakland, Cal.

CARPENDER, SYDNEY B., Vice-Pres.,
Brunswick Refrigerating Co., New Brunswick, N. J.

CHAMBERLAIN, FREDERICK H., Genl. Mgr.,
Alabama Power Co., Birmingham, Ala.

CHAMP, JOSEPH H., Pres.,
Iceless Machine Co., Cleveland, Ohio

CLARK, WILLIAM L., Supt. of Power,
West Point Mfg. Co., West Point, Ga.

CLEVELAND, CLARENCE E., Mfr.,
Intervale Mills, Quinebaug, Conn.

COLLINS, PALMER, Asst. Supt.,
American Steel & Wire Co., South Works, Worcester, Mass.

CONN, THOMAS D., Engrg. Dept.,
Poole Engineering & Machine Co., Baltimore, Md.

COOK, GLENN W., Insptr.,
Travelers Ins. Co., Cleveland, Ohio

COOK, JAMES C., Vice-Pres.,
The J. B. McCrary Co., Municipal Engrs., Atlanta, Ga.

CORPUT, REX V., Captain,
Coast Artillery Corps, U. S. Army, Fort Pickens, Fla.

CRAWFORD, THOMAS G., Supvr. of Drafting,
General Electric Co., Pittsfield, Mass.

DARLINGTON, WAYNE, Consulting Engineer, Georgetown, S. C.

DAVOL, FRANK H., Jr.,
Mech. Engr. and Exporter, New York

DICKERSON, WALTER H., Secy. and Plant Mgr.,
Muskegon Extract Co., Muskegon, Mich.

DUNBAR, HAROLD F., Mech. Engr.,
Keith Paper Co., Turners Falls, Mass.

DURBIN, FLETCHER M., Asst. Genl. Mgr.,
The Sefton Mfg. Co., Chicago, Ill.

EGLESTON, OLIVER J., Engineer in charge of design,
United States Smelting Co., Blackwell, Okla.

EVANS, POWELL, Pres.,
Merchant & Evans Co., Philadelphia, Pa.

FIELD, FREDERICK C., Pres. and Genl. Mgr.,
Standard Arms Mfg. Co., Wilmington, Del.

FIELD, HERBERT E., Pres.,
Wheeling Mold & Fdy. Co., Wheeling, W. Va.

FISHER, WILLIAM C., Asst. Supt.,
The Flatbush Gas & Elec. Co. Brooklyn, N. Y.

FORTNEY, CAMDEN P., Asst. Engr.,
U. S. Engineer Dept., U. S. Army, Louisville, Ky.

FUQUA, LAWRENCE M., Genl. Foreman,
Southern Rwy. Co., Monroe, Va.

GABY, FREDERICK A., Chief Engr.,
Hydro Electric Power Commission of Ontario, Toronto, Canada.

GARRETT, SEYMOUR S., Asst. Prof. Mech. Engrg.,
Sibley College, Cornell Univ., Ithaca, N. Y.

GOETZ, JOHN, Works Mgr.,
Kempsmith Mfg. Co., Milwaukee, Wis.

GRANT, GEORGE P., JR., Treas.,
Grant Yarn Co., Fitchburg, Mass.

HALL, JOHN A.,
with Cleveland Machinery & Supply Co., New York

HAM, CLARENCE W., Asst. Professor of Mch. Design,
Cornell University, Ithaca, N. Y.

HAMPSON, DONALD A., Engineer,
Morgans & Wilcox Mfg. Co., Middletown, N. Y.

HARRIS, ALBERT J. B., Mech. Engr.,
Merchants Despatch Transportation Co., E. Rochester, N. Y.

HAZLEHURST, JAMES N.,
Consulting Engineer, Chattanooga, Tenn.
HECK, GEORGE D., Designer,
The S. S. White Dental Mfg. Co., Prince Bay, N. Y.
HELWIG, ALFRED, Engr. Steam Operation,
Edison Electric Illuminating Co., Brooklyn, N. Y.
HIGGINS, ALDUS C., Secy.,
Norton Company, Worcester, Mass.
HOOD, RICHARD H.,
Retired Contracting Engineer, New York
HORBACH, PAUL W., Secy.,
Woolf Graphite Lubricator Co., Inc., Omaha, Nebr.
HUGHES, JAMES W., Genl. Mgr.,
Defiance Mfg. Co., Philadelphia, Pa.
HUNTER, DAVID E., Constr. Engr.,
The Shaw-Walker Co., Muskegon, Mich.
HUTCHINSON, HENRY H., Supt., Vaudreuil Works,
Canadian Explosives, Ltd., Vaudreuil, Que., Canada
JENKS, WALTER H., Vice-Pres.,
The Marathon Tire & Rubber Co., Cuyahoga Falls, Ohio
JOHNSON, EDMUND R., Chief Engr.,
Haslett Spiral Chute Co., Philadelphia, Pa.
JOHNSON, NELSON C., Secy.,
Foster Merriam & Co., Meriden, Conn.
JONES, LLOYD B., Asst. Engr. Motive Pwr.,
Pennsylvania R. R., Williamsport, Pa.
KEITH, JAMES, Chief Engineer,
James Keith & Blackman Co., London, England
KELLY, WILLIAM M., Mgr., Kelly Press Dept.,
American Type Founders' Co., Jersey City, N. J.
KENFIELD, LOUIS E., Charge of Tool Design,
R. Hoe & Co., New York
KIMBERLEY, JOHN A., Jr.,
with Paine Lumber Co., Ltd., Oshkosh, Wis.
KIRK, JAY B., Pres.,
J. B. Kirk Gas & Smelting Co., Iola, Kan.
LARSEN, OTHMAR I., Supt.,
Canadian-Fairbanks-Morse Co., Ltd., Toronto, Canada
LAWRENCE, SAMUEL E., Junior Mech. Engr.,
U. S. Engr. Dept., Dam No. 43, Ohio River, Pilcher, Ky.
LEE, GILMER T., Chief Engineer,
Solvay Process Co., Hutchinson, Kan.
LINDBERG, INGUSTINUS J., Mech. Engr. and Asst. Supt.,
Abendroth & Root Mfg. Co., Newburgh, N. Y.
LONG, HOWARD E., Chief Draftsman and Designer,
American District Steam Co., North Tonawanda, N. Y.
LOTZ, CHARLES W., Chief Engineer,
Coxe Travelling Grate Co., Port Carbon, Pa.
LUCAS, CLARENCE W., Mech. Engr.,
Faries Mfg. Co., Decatur, Ill.
McGAHEY, CALVERT R.,
with Crook-Kries Co., Baltimore, Md.
McKENNEY, PAUL K., Treas. and Genl. Mgr.,
Texas Cotton Mill Co., McKinney, Tex.
MEISTERHUTT, HERBERT,
with De La Vergne Mch. Co., New York
MERKT, OSWALD L., Engineer in charge,
Westinghouse, Church, Kerr & Co., New York
MERRILL, CARLE J., Pres.,
C. J. Merrill Inc., Portland, Me.
MIDDLETON, H. A., Estimating Engr.,
Crane Co., Birmingham, Ala.
MONROE, F. ADAIR, JR., Vice-Pres.,
The Dyer Co., Cleveland, Ohio
MOORE, HUGH K., Chief Chemist, Berlin Mills,
Burgess Sulphite Fibre Co., Berlin, N. H.
MUNSON, HORACE D., Mech. Engr.,
American Encaustic Tiling Co., Ltd., Zanesville, Ohio
NALON, THOMAS M., Chief Engineer,
Pratt & Ford, Cons. Engrs., Atlanta, Ga.
NIEMEYER, JOHN, Mgr., Engrg and Statistical Depts.,
Baker, Vawter & Wolf, Chicago, Ill.
NOBLE, HARVEY S., Asst. Road Foreman of Engines,
Penn. R. R., Renovo, Pa.
OAKES, WILLIAM H., Vice-Pres.,
Buerkel & Co., Inc., Boston, Mass.
OLDS, ALFRED W.,
with Power Manufacturing Co., Lima, Ohio
PECK, JOHN, Ch. Insptr.,
Steam Boilers and Mchy., New Westminster, B. C., Canada
POLK, ROGER W., Cons. Gas. Engr. Providence, R. I.
PRATT, ARTHUR D., Asst. to Advisory Engr.,
The Babcock & Wilcox Co., New York
PRINDLE, HARRY B., Export Dept.,
G. P. Morgan & Co., New York
QUINN, EDWARD O., Mechanical and Civil Engineer,
Cowell Portland Cement Co., Cowell, Cal.
RALPH, PAUL J., Mgr. Power Plant,
The N. K. Fairbank Co., Chicago, Ill.
RAYNER, CYRUS T., JR., Asst. Eng.,
Board of Levee Commissioners of Orleans Levee District,
New Orleans, La.
RAMSAY, WILLIAM G., Vice-Pres. and Chief Engineer,
E. I. du Pont de Nemours & Co., Wilmington, Del.
REED, WILLIAM S., Cons. Mech. Engr., Partner,
Reed & Glaser, Indianapolis, Ind.
RIDER, Joseph B., Consulting Engineer, New York
ROBERTS, THEODORE C., Chief Engineer,
United Verde Copper Co., Jerome, Ariz.
ROGERS, CHARLES O., Chief Engr.,
The Charles J. Jager Co., Boston, Mass.
ROWLEY, HORACE T., Vice-Pres.,
Standard Compress & Warehouse Corp., New York
SARGISSON, ZACCHEUS E., Designing Engr.,
Illinois Traction System, Peoria, Ill.
SEYMOUR, CHARLES R., Chief Draftsman,
M. D. Knowlton Co., Rochester, N. Y.
SHALLCROSS, AUGUSTUS W., Draftsman and Designer,
Layne & Bowler Co., Houston, Tex.
SMITH, HERMAN R., Mech. Engr.,
Raymond Concrete Pile Co., New York
SMITH, THOMAS A., Works Engineer's Dept.,
Union Metallic Cartridge Co., Bridgeport, Conn.
SMITHWICK, NATHANIEL A., Formerly Chief Engr.,
Goulds Mfg. Co., Seneca Falls, N. Y.
STOCK, WILLIAM A.,
Patent Attorney, Oakland, Cal.
TAUSSIG, JOHN H., Engineer of Design,
The United Gas Improvement Co., Philadelphia, Pa.
THORSBY, KARL J., Engineer,
California Corrugated Culvert Co., W. Berkeley, Cal.
TOWNSEND, HARRY W., Factory Manager,
Aldrich Pump Co., Allentown, Pa.
VAN WORMER, RALPH B., Genl. Foreman Motive Pwr.,
Atlantic Coast Line R. R., Waycross, Ga.
VOORHEES, LEE J., Designer,
The Celluloid Co., Newark, N. J.
VREELAND, ELMER L., Genl. Foreman,
Melli Machine Tool & Die Co., Newark, N. J.
WALSH, FRANCIS, Chief Engineer, S. S. Havana,
Ward Line, New York
WEBER, AUGUST, Jr., Vice-Pres.,
Weber Electric Co., Schenectady, N. Y.
WETMORE, WADE L., Mech. Engr.,
Granby Consolidated Mining, Smelting & Power Co., Ltd.,
Anyox, B. C., Canada
WILSON, JAMES H., Formerly Mech. Engr.,
McCleary, Wallin & Crouse, Amsterdam, N. Y.
WINE, WILLIAM E., Pres.,
The Wine Railway Appliance Co., Toledo, Ohio
YINGLING, FRANK B., Secy.,
The Ceramic Mchy. Co., Hamilton, Ohio

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

AVNSOE, OSKAR O. T., Mech. Engr.,
The Iola Portland Cement Co., Iola, Kan.
BAKER, C. T., Chief Engr.,
Southern Utilities Co., Jacksonville, Fla.
BARANY, EDMUND, Machine Designer,
Singer Mfg. Co., Elizabethport, N. J.
BIRKENBEUL, CLARENCE E., Draftsman,
The Holt Mfg. Co., Stockton, Cal.
BROEKER, FREDERICK G., Mech. Draftsman,
Braden Copper Co., Rancagua, Chile
BRYSON, TANDY A., Engineer,
Tolhurst Machine Works, Troy, N. Y.
BULLARD, MAURICE L., Chief Engineer,
W. H. McElwain Co., Manchester, N. H.
BYLUND, WALTER R., Charge Publicity Dept.,
Hyatt Roller Bearing Co., Newark, N. J.
CABLE, DAVIS A., Genl. Supt.,
The United States Roofing Tile Co., E. Sparta, Ohio
CLEMMER, DAVID P., Asst. Supt.,
Southern Stove Works., Richmond, Va.
COLBY, CLYDE W.,
with National Regulator Co., Toledo, Ohio
DAGAVARIAN, NISHAN A., Mech. Draftsman,
Nordyke & Marmon Co., Indianapolis, Ind.
DONAHUE, BARTHOLOMEW A.,
with Pratt & Whitney Co., Hartford, Conn.
EAGAN, HENRY E., Manager Dublin Branch,
Atlantic Ice & Coal Corp., Dublin, Ga.
ESTWING, ERNEST O., Industrial Engineer,
Remington Typewriter Co., Yost Works, Bridgeport, Conn.
FEAR, THOMAS G., Superintendent, Bay View Div.,
Tenn. Coal, Iron & R. R. Co., Birmingham, Ala.

FICKES, ALFRED C., Mech. Engr.,
Lancaster Iron Works, Lancaster, Pa.
FISCHER, OTTO W., Chief Draftsman,
L. O. Koven & Bro., Jersey City, N. J.
FRANKEL, MONROE J., Asst. Insptr. Gas & Electricity,
City of Louisville, Ky.
GATES, SAM J., Commercial Engineer,
The Milwaukee Elec. Rwy. & Light Co., Milwaukee, Wis.
GREGG, ROBERT, Secy.,
Atlantic Steel Co., Atlanta, Ga.
GEDDIS, ROBERT H.,
with Jones & Laughlin Steel Co., Pittsburgh, Pa.
HANSEN, HERBERT C., Office Engineer,
City Light & Water Co., Amarillo, Tex.
HARVISON, LOUIS H., Engineer,
The M. W. Kellogg Co., New York
HENDRIE, GEORGE A., Plant Supt.,
Ammo-Phos Corporation, Warner's, N. J.
HOOVER, CLAYTON A.,
with Southwark Fdy. & Mch. Co., Philadelphia, Pa.
JACOBSON, FRANZ,
with Pressed Steel Car Co., Pittsburgh, Pa.
KEHOE, DANIEL E.,
Kehoe's Iron Works, Savannah, Ga.
LAPHAM, JARED S., Adjunct Professor of Exper. Engrg.,
University of Virginia, University, Va.
LEWIS, WARREN D., Asst. Engr.,
Edison Electric Illuminating Co., Brooklyn, N. Y.
LITTLE, EDWIN R., Mech. Engr., Member of Firm,
Little & Shepard, Mech. and Elec. Engrs., Detroit, Mich.
McCORD, CHARLES D., Chief Electrician,
The Carbon Limestone Co., Edenburg, Pa.
MACKINTOSH, EDWARD B., Drafting,
American Brass Co., Torrington, Conn.
MALM, CARL P. A., Marine Draftsman,
Newport News Shipbuilding & Dry Dock Co., Newport News, Va.
MEYNCKE, GEORGE M., Head of Educational Dept.,
The Dayton Engrg Laboratories Co., Dayton, Ohio
MEYER, ARTHUR E., Sheet-Metal Specialist,
The Pressed Metal Mchy. Co. (Owner), Chicago, Ill.
MURRAY, ETHAN F.,
with Lummus Cotton Gin Sales Co., Dallas, Tex.
OSBORNE, ROBERT E., Chief Engineer,
Bayard Chemical Co., Inc., Woodbridge, N. J.
OWENS, ROBERT H., Instructional Corps,
Purdue University, Lafayette, Ind.
PATERSON, WILLIAM, Testing Engr.,
Armour & Co., Chicago, Ill.
QUINLIVAN, EDWARD C., Steam Engr.,
U. S. E. D. Troy, N. Y.
ROBINSON, MAX B., Shop Co-ordinator,
University of Cincinnati, Cincinnati, Ohio
SANCHEZ, JULES A.,
with W. F. Wendt Publishing Co., Buffalo, N. Y.
SCHULTZ, WILLIAM W., Asst. to Engr. of Constr.,
The Barrett Co., New York
SEMANS, FRANK W.,
with Cambria Steel Co., Johnstown, Pa.
SERVICE, JESSE S., Draftsman,
The Babcock & Wilcox Co., Bayonne, N. J.
SHERMAN, WALDO L., Asst. Mech. Engr.,
Boston Woven Hose & Rubber Co., Cambridge, Mass.
SPENCER, FURMAN G., Efficiency Engineer,
The Emerson Co., Chicago, Ill.
STEPHEN, CHARLES W., In charge of experimental work,
Crane Co., Bridgeport, Conn.
SWAIN, PHILIP W., Instr. in Mech. Engrg., S. S. S.,
Yale University, New Haven, Conn.
TURNER, CHANNING, Asst. to Indus. Engr., Gun Dept.,
Winchester Repeating Arms Co., New Haven, Conn.
VENNEMA, AUGUSTUS W., Engineer,
The Manhattan Rubber Mfg. Co., Passaic, N. J.
VOORHEES, JOHN R., Service Engineer,
United Piece Dye Works, Lodi, N. J.
WATTS, ROBERT B., Chief Engineer,
Eastern State Hospital, Williamsburg, Va.
WEAVER, GILBERT G., Supervisor,
York Co-operative Industrial School, York, Pa.
WEBER, JOHN, Asst. Prof Mech. Engrg.,
Univ. of Pittsburgh, Pittsburgh, Pa.
WINTERCORN, JOHN, JR., Machine Designer,
Joseph T. Ryerson & Son, Chicago, Ill.
WYMAN, LAURENCE W., Estimator and Designer,
California Corrugated Culvert Co., W. Berkeley, Cal.

FOR CONSIDERATION AS JUNIOR

ANDERSON, OSCAR A., Office Engrg.,
Armour & Co., Chicago, Ill.
BAXTER, WILLIAM C., Mech. Engr.,
Wichita Pipe Line Co., Bartlesville, Okla.
BIRDSEYE, GARNER K.,
with Remington Arms Union Metallic Cartridge Co.,
Bridgeport, Conn.
BONAWITZ, DAVID J., Designer,
Pyrene Mfg. Co., New York
BORROMEO, CANUTO O.,
with The Vitter Mfg. Co., Milwaukee, Wis.
BRAUER, RUDOLPH C., Draftsman,
City Engrg. Dept., Richmond, Va.
BROWN, CARLTON L., Safety Engr.,
The B. F. Goodrich Co., Akron, Ohio
BROWN, EDMUND K.,
with Lake Torpedo Boat Co., Bridgeport, Conn.
CHAPIN, HARRY A., Asst. to Vice-Pres.,
American Lead Pencil Co., Hoboken, N. J.
CHAPIN, HENRY L., Grad. Student,
Purdue University, Lafayette, Ind.
COBB, H. ELMORE, Asst. Engr., Dept. of Production Control,
Remington Arms U. M. C. Co., Bridgeport, Conn.
COLLYER, WILLIAM C.,
with Ingersoll-Rand Co., Juneau, Alaska
CONNELL, EARLE W., Asst. Chief Engr., Power Plants,
American Agricultural Chemical Co. Pierce, Fla.
CROSS, CHARLES D.,
with New York Central R. R. Co., Elkhart, Ind.
CURTIS, AARON B., JR.,
with Crandall Packing Co., Cleveland, Ohio
DAYTON, BIRGE S., Asst. Mech. Engr.,
The Mechanical Efficiency Co., Akron, Ohio
DONATH, WILLIAM T., Asst. to Asst. Supt.,
Remington Arms U. M. C. Co., Bridgeport, Conn.
ELMENDORF, HAROLD H.,
with The Aultman & Taylor Mchy. Co., Mansfield, Ohio
FISHER, SYDNEY, Electrical Engineer,
The Remington Arms Co., Bridgeport, Conn.
FITZSIMONS, JOHN E., Draftsman,
Pyrene Mfg. Co., New York
GOODIER, HOMER W., Engrg. Dept.,
Cayuga Cement Corp., Portland Point, N. Y.
GRAY, H. LIGGETT,
with Valvoline Oil Co., New York
GUITERAS, JULIAN G.,
Hall-Scott Motor Car Co., W. Berkeley, Cal.
HAWKINS, ROBERT D.,
with Remington Arms Co., Eddystone, Pa.
HENRY, ALEXANDER S., JR., Student,
Columbia University, New York
HENRY, HAROLD W., Mech. Engr.,
Sherman & Co., Mineville, N. Y.
KEELER, EDWIN H., Engr.,
Ousatonic Water Power Co., Derby, Conn.
KELLER, PARRY,
with Reed-Prentice Co., Worcester, Mass.
LAMOREE, JAMES K., Asst. Master Mech., Shenango Wks.,
American Sheet & Tin Plate Co., New Castle, Pa.
LESCHINSKY, FREDERIC J., Student,
University of Nebraska, Lincoln, Nebr.
LINCOLN, CLOVIS W., Mech. Engr.,
Curtiss Aeroplane Co., Buffalo, N. Y.
LOVE, THOMAS J., Asst. Mech. Engr.,
The Dodge Sales & Engrg. Co., New York
McCUE, JOHN M., Draftsman, Bridge Dept.,
Chesapeake & Ohio Rwy. Co., Richmond, Va.
MANIER, RALPH L., Machine Insptr.,
U. S. E. D., Troy, N. Y.
MENDEZ, ALVARO,
with Pressed Steel Car Co., McKees Rocks, Pa.
MOON, ALFRED G.,
with Hercules Power Co., Kenvil, N. J.
MORRISON, BARRETT W., Apprentice,
Westinghouse Mch. Co., E. Pittsburgh, Pa.
NIELSEN, LAWRENCE H.,
with Public Service Electric Co., Newark, N. J.
OCHTMAN, LEONARD, JR., Asst. Engr.,
Van Bierck Motor Co., Monroe, Mich.
PETER, ALBERT G., Efficiency Engineer,
Chain Belt Co., Milwaukee, Wis.
PETERS, CLIFFORD H., Engineer,
The L. L. Harr Corp., Cleveland, Ohio
PHELPS, JOHN T.,
with General Electric Co., Everett, Mass.
RAYSOR, EARL L.,
Brier Hill Steel Co., Youngstown, Ohio
ROGERS, THEODORE B.,
with Buckeye Cotton Oil Co., Jackson, Miss.

RUSSELL, TROY,
with Toledo Furnace Co., Toledo, Ohio
ST. CLAIR, PALMER, JR.,
with E. I. du Pont de Nemours & Co., City Point, Va.
SETH, GEORGE L.,
with The Leeds & Northrup Co., Philadelphia, Pa.
SICKENBERGER, ERNEST F., JR.,
with Western Electric Co., New York
SMITH, PETER P., JR., Engrg. and Drafting,
Robert Sayre Kent, Cons. Engrs., Brooklyn, N. Y.
STEM, CLIFFORD H., Asst. to City Engr., New Orleans, La.
STOLL, JOHN, JR.,
with The Remington Arms & Ammunition Co., Bridgeport, Conn.
STRAUSS, JEROME, Chemist and Metallurgist,
Western Drop Forge Co., Marion, Ind.
TEAGUE, NEWTON N.,
with Augusta-Aiken Rwy. & Elec. Corp., Augusta, Ga.
VAN DENBURGH, OTIS A., JR., Engrg. Dept.,
Cambria Steel Co. Johnstown, Pa.
VIEDT, HAROLD B., Cadet Engr.,
Public Service Electric Co., Jersey City, N. J.
WALLACE, ROBERT H., Exper. Engr.,
Remington Arms & Ammunition Co., Bridgeport, Conn.
WIGHTMAN, GEORGE A., Asst. to Chief Engineer,
Hawthorne Paper Co., Kalamazoo, Mich.
WISSCHUSEN, WALTER, Exper. Engrg.,
The Barrett Co., New York
WOOD, HAROLD J.,
with Remington Arms U. M. C. Co., Bridgeport, Conn.
WORK, CLAYTON W., Erecting Engr.,
Westinghouse Elec. & Mfg. Co., New York
YAGER, JOHN E., Draftsman,
Bucyrus Co., So. Milwaukee, Wis.

APPLICATIONS FOR CHANGE OF GRADING

PROMOTION FROM ASSOCIATE-MEMBER

DOWD, BERNARD J.,
with Royal Typewriter Co., Inc., Hartford, Conn.
SEATON, ROY A., Prof. of Applied Mechanics and Mch. Design,
Kansas State Agri. College, Manhattan, Kan.

PROMOTION FROM JUNIOR

BORCHARDT, ALBERT H.,
with Worthington Pump & Machy. Co., Harrison, N. J.
DOOLITTLE, HAROLD L., Asst. Constr. Engr.,
Southern California Edison Co., Los Angeles, Cal.
DUDLEY, SAMUEL W., Chief Engineer,
Westinghouse Air Brake Co., Wilmerding, Pa.
FARR, ARTHUR V., Tech. Publicity Mgr.,
S K F Ball Bearing Co., Hartford, Conn.
GRANT, ALBERT W., JR.,
with The United Gas Improvement Co., Philadelphia, Pa.
HATMAN, JULIUS G., Efficiency Engr.,
Senet Solvay Co., Ensley, Ala.
WILBUR, RALPH S., Asst. Prof. of Steam Engrg.,
State Univ. of Iowa, Iowa City, Ia.

SUMMARY

New Applications	236
Applications for change of grading:	
Promotion from Associate-Member	2
Promotion from Junior	7
Total	245

GEOGRAPHICAL LIST

(Applications for promotion from any grade will be indicated by the initials of that grade)

Alabama
Birmingham—Chamberlain, F. H.
Fear, T. G.
Middleton, H. A.
Ensley—Hatman, J. G. (J.)
Alaska
Juneau—Collyer, W. C.
Arizona
Jerome—Roberts, T. C.
California
Cowell—Quinn, E. O.
Los Angeles—Doolittle, H. L. (J.)
Oakland—Bunker, W. D.
Stock, W. A.
San Francisco—Belcher, P. W.
Stockton—Birkenbeul, C. E.
W. Berkeley—Guiteras, J. G.
Thorsby, K. J.
Wyman, L. W.
Canada
Anyox—Wetmore, W. L.
Montreal—Bristol, C. F.
New Westminster—Peek, J.
St. John—Benjamin, L. S.
Toronto—Gaby, F. A.
Larsen, O. I.
Vandreuil—Hutchinson, H. H.
Connecticut
Bridgeport—Birdseye, G. K.
Brown, E. K.
Cobb, H. E.
Donath, W. T.
Estwing, E. O.
Fisher, S.
Smith, T. A.
Stephen, C. W.
Stoll, J., Jr.
Wallace, R. H.
Wood, H. J.
Derby—Keeler, E. H.
Hartford—Baldwin, H. G.
Donahue, B. A. (A. M.)
Dowd, B. J.
Farr, A. V. (J.)
Meriden—Johnson, N. C.
New Haven—Swain, P. W.
Turner, C.
Quinebaug—Cleveland, C. E.
Torrington—Mackintosh, E. E.
Delaware
Wilmington—Field, F. C.
Ramsay, W. G.
District of Columbia
Washington—Adelman, A.
Florida
Ft. Pickens—Corput, R. V.
Jacksonville—Baker, C. T.
Pierce—Connell, E. W.
Georgia
Atlanta—Cook, J. C.
Gregg, R.
Nalon, T. M.
Augusta—Teague, N. H.
Dublin—Eagan, H. E.
Savannah—Kehoe, D. E.
Waycross—Van Wormer, R. B.
West Point—Clark, W. L.
Illinois
Aurora—Bodinson, L. W.
Chicago—Anderson, O. A.
Ralph, P. J.
Durbin, F. M.
Meyer, A. E.
Niemeyer, J.
Paterson, W.
Spencer, F. G.
Wintercorn, J., Jr.
Decatur—Lucas, C. W.
Peoria—Sargisson, Z. E.
Indiana
Elkhart—Cross, C. D.
Indianapolis—Dagavarian, N. A.
Reed, W. S.
Lafayette—Chapin, H. L.
Owens, R. H.
Marion—Strauss, J.
Iowa
Iowa City—Wilbur, R. S. (J.)
Louisiana
New Orleans—Rayner, C. T., Jr.
Stem, C. H.
Kansas
Hutchinson—Lee, G. T.
Iola—Avnsoe, O. O. T.
Kirk, J. B.
Manhattan—Seaton, R. A. (A. M.)
Kentucky
Louisville—Fortney, C. P.
Frankell, M. J.
Pilcher—Lawrence, S. E.
Maryland
Baltimore—Conn, T. D.
McGahey, C. R.
Massachusetts
Boston—Oakes, W. H.
Robers, C. O.
Cambridge—Sherman, W. L.
Everett—Phelps, J. T.
Fitchburg—Grant, G. P., Jr.
Pittsfield—Crawford, T. G.
Turners' Falls—Dunbar, H. F.
Worcester—Collins, P.
Higgins, A. C.
Keller, P.
Maine
Portland—Merrill, C. J.
Michigan
Detroit—Little, E. R.
Kalamazoo—Wightman, G. A.
Monroe—Ochtman, L., Jr.
Muskegon—Dickerson, W. H.
Hunter, D. E.
Mississippi
Jackson—Rogers, T. B.
Nebraska
Lincoln—Leschinsky, F. J.
Omaha—Horbach, P. W.
New Hampshire
Berlin—Moore, H. K.
Manchester—Bullard, M. L.
New Jersey
Bayonne—Service, J. S.
Chrome—Brower, C. L.
Elizabethport—Barany, E.
Harrison—Borchardt, A. H. (J.)
Hoboken—Chapin, H. A.
Jersey City—Fischer, O. W.
Kelly, W. M.
Viedt, H. B.
Kenvil—Moon, A. G.
Lodi—Voorhees, J. R.
Newark—Bylund, W. R.
Nielsen, L. H.
Voorhees, L. J.
Vreeland, E. L.
New Brunswick—Carpender, S. B.
Passaic—Vennema, A. W.
Warner's—Hendrie, G. A.
Woodbridge—Osborne, R. E.
New York
Amsterdam—Wilson, J. H.
Brooklyn—Bisbee, D. A.
Fisher, W. C.
Helwig, A.
Lewis, W. D.
Smith, P. P., Jr.
Buffalo—Lincoln, C. W.
Sanchez, J. A.
E. Rochester—Harris, A. J. B.
Ithaca—Garrett, S. S.
Ham, C. W.
Newburgh—Lindberg, I. J.
Middletown—Hampson, D. A.
Mineville—Henry, H. W.
New York—Bonawitz, D. J.
Davol, F. H., Jr.
Fitzsimons, J. E.
Gray, H. L.
Hall, J. A.
Harvison, J. H.
Henry, A. S., Jr.
Hood, R. H.
Kenfield, L. E.
Love, T. J.
Meisterhutt, H.
Merkt, O. L.
Pratt, A. D.
Prindle, H. B.
Rider, J. B.
Rowley, H. T.
Schultz, W. W.
Sickenberger, E. F., Jr.
Smith, H. R.
Walsh, F.
Wisschusen, W.
Work, C. W.
Portland Pt.—Goodier, H. W.
Rochester—Seymour, C. R.
Schenectady—Weber, A., Jr.
Seneca—Smithwick, N. A.
Troy—Bryson, T. A.
Manier, R. L.
Quinlivan, E. C.
Ohio
Akron—Brown, C. L.
Dayton, B. S.
Bucyrus—Brown, D.
Cincinnati—Robinson, M. B.

Cleveland—Champ, J. H.
Cook, G. W.
Curtis, A. B., Jr.
Monroe, F. A., Jr.
Peters, C. H.
Cuyahoga Falls—Jenks, W. H.
Dayton—Meyncke, G. M.
Hamilton—Yingling, F. B.
Lima—Olds, A. W.
Mansfield—Bliss, A. L.
Elmendorf, H. H.
Sparta—Cable, D. A.
Toledo—Colby, C. W.
Russell, T.
Wine, W. E.
Youngstown—Raysor, E. L.
Zanesville—Munson, H. D.

Oklahoma
Bartlesville—Baxter, W. C.
Blackwell—Egleston, O. J.

Pennsylvania
Allentown—Townsend, H. W.
Beaver Falls—Bentley, L. L.
E. Pittsburgh—Morrison, H. W.
Edenburg—McCord, C. D.
Eddystone—Bilger, H. E.
Hawkins, R. D.
Johnstown—Semans, F. W.
Van Denburgh, C. A., Jr.
Lancaster—Fickes, A. C.
McKees Rocks—Mendez, A.
New Castle—Lamoree, J. K.
Philadelphia—Bergman, L. H.
Evans, P.
Grant, A. W., Jr. (J.)
Hoover, C. A.
Hughes, J. W.
Johnson, E. R.
Taussig, J. H.
Pittsburgh—Jacobson, F.
Seth, G. L.
Weber, J.
Port Carbon—Lotz, C. W.
Renovo—Noble, H. S.
Williamsport—Jones, L. B.
Wilmerding—Dudley, S. W. (J.)
York—Weaver, G. G.

Rhode Island
Providence—Polk, R. W.

South Carolina
Georgetown—Darlington, W.

Tennessee
Chattanooga—Hazlehurst, J. N.
Maryville—Biggs, W. E.

Texas
Amarillo—Hansen, H. C.
Dallas—Murray, E. F.
Houston—Shallcross, A. W.
McKinney—McKenney, P. K.

Virginia
City Point—St. Clair, P., Jr.
Newport News—Malm, C. P. A.
Monroe—Fuqua, L. M.
Richmond—Brauer, R. C.
Clemmer, D. P.
McCue, J. M.
University—Lapham, J. S.
Williamsburg—Watts, R. B.

West Virginia
Wheeling—Field, H. E.

Wisconsin
Milwaukee—Borromeo, C. O.
Gates, S. J.
Goetz, J.
Peter, A. G.
Yager, J. E.
Oshkosh—Kimberley, J. A., Jr.

Chile
Rancagua—Broeker, F. G.

England
London—Keith, J.

PERSONALS

IN these columns are inserted items concerning members of the Society and their professional activities. Members are always interested in the doings of their fellow-members, and the Society welcomes notes from members and concerning members for insertion in this section. All communications of personal notes should be addressed to the Secretary and items should be received by the 18th of the month in order to appear in the succeeding issue of The Journal.

CHANGES OF POSITION

HERBERT J. WHITE has accepted a position with the Ross Rifle Company of Quebec, Canada.

EDWARD SCHILDHAUER has assumed the presidency of the Artillery Fuse Company of Wilmington, Del.

HUGH L. THOMPSON has accepted a position with the A. S. Cameron Steam Pump Works, St. Louis, Mo.

WALTER J. SYKES has accepted a position with the Canadian Copper Company, Copper Cliff, Ont., Canada.

LOUIS MARDAGA has become associated with the Mickle-Milnor Engineering Company of Philadelphia, Pa.

DAVID B. MORGAN has become affiliated with the Carolina Wood Products Company, Asheville, N. C.

BURT C. WEAR, formerly connected with the Youngstown Sheet and Tube Company, Youngstown, O., has entered the employ of the Gary Tube Company.

ARTHUR S. HAWKS has accepted a position with the Busch Sulzer Bros.-Diesel Engine Company, St. Louis, Mo., in the capacity of assistant chief engineer.

STEVENSON TAYLOR, until recently vice-president of the Quintard Iron Works Company, New York, has assumed the presidency of the American Bureau of Shipping, New York.

FRANKLIN W. GILMAN, now associated with the B. F. Sturtevant Company, Chicago, Ill., was formerly connected with the Sanford Riley Stoker Company, Ltd., of Worcester, Mass.

PERRY R. CASSIDY, formerly assistant professor of thermodynamics, University of Kentucky, Lexington, Ky., has accepted a position with the Babcock and Wilcox Company, Barberton, O.

L. S. VOIGT, formerly mechanical engineer with the Hydraulic Press Manufacturing Company, Mt. Gilead, O., is now employed in the coke and by-products department of the Illinois Steel Company of Gary, Ind.

LLOYD W. GANSCHOW, formerly electrolysis engineer of the Central Union Telephone Company, Columbus, O., has become associated with the Western Union Telegraph Company, Cleveland, O., in a similar capacity.

ARCHER DAVIDSON, district engineer of the Westinghouse Machine Company, Atlanta, Ga., is now connected with the Westinghouse Electric and Manufacturing Company, Boston, Mass., in the capacity of salesman.

ALBERT W. GRANT, JR., formerly identified with the photometrical department of the United States Improvement Company, Philadelphia, Pa., has accepted a position with the H. Koppers Company of Pittsburgh, Pa.

F. DONALD FENHAGEN, formerly associated with Henry Adams, consulting engineer of Baltimore, Md., as assistant engineer, has become designing engineer with the Barrett Company of Frankford, Philadelphia, Pa.

A. L. G. FRITZ has assumed the position of general superintendent of construction of the Oliver and Hill Construction Company, Kingsport, Tenn. He was until recently connected with Ford, Bacon and Davis of the same city.

FREDERIC O. EBELING, formerly engineer and draftsman of the Robins Conveying Belt Company, New York, has become associated with the engineering department of the Gifford-Wood Company, Hudson, N. Y., as sales engineer.

D. RAYMOND MCNEAL has resigned his position with the Westinghouse Machine Company, East Pittsburgh, Pa., and has entered the employ of the Dravo-Doyle Company of Pittsburgh, Pa., with headquarters in the Philadelphia office.

HAROLD K. BEACH, until recently connected with the staff of Lockwood, Greene and Company, New York, has accepted the position of mechanical superintendent of the Bronze, Copper and Brass Rolling Mills, New Toronto, Ont., Canada.

WALTER P. ALEXANDER has resigned as engineer and works manager of the Providence Engineering Works, Providence, R. I., to become steam and mechanical engineer of The Moulton Engineering Corporation, consulting engineers of Portland, Me.

FREDERICK R. PRATT, formerly in the employ of the Berkshire Cotton Manufacturing Company, Adams, Mass., as master mechanic and chief engineer, has joined the staff of Bird and Sons of East Walpole, Mass., in the capacity of mechanical engineer.

FRED C. NICHOLS has become affiliated with the engineering department of The Great Western Sugar Company, Denver, Colo., in the capacity of traveling engineer. He was until recently assistant engineer of the department of terminal construction of the Panama Canal, Balboa Heights, Canal Zone.

STERLING H. BUNNELL has resigned from his engineering and sales connection with the Griscom-Russell Company, New York, which has extended over the past nine years, and has become chief engineer of R. Martens and Company, Inc., the New York connection of R. Martens and Company, Ltd., of London.

ANNOUNCEMENTS

THEODORE A. LEISEN was elected vice-president of the American Water-Works Association.

LEONARD METCALF was unanimously elected president of the American Water-Works Association.

WILLIAM VON PHUL will succeed Charles N. Blake as vice-president of the United Railways of San Francisco.

ARTHUR M. WAITT has removed his offices from 165 Broadway, New York, to the Putnam Building, 2 W. 45th St., New York.

WYNN MEREDITH has resigned from the Electricity Commission of the city of Alameda, Cal., because of the pressure of other business.

EDWIN B. KATTE was elected one of the vice-presidents of the New York Electrical Society at the annual meeting in New York City, June 14.

WILLIAM SMITH, who has been with the Pennsylvania Steel Company since leaving the Jones and Laughlin Company three years ago, has resigned.

J. L. MOORE, for the past seven years chief engineer of the Kerr Turbine Company, Wellsville, N. Y., has severed his connection with the company.

W. H. VAN DERVOORT, president of the Moline Automobile Company, has been elected president of the National Metal Trades Association, New York.

HARDY S. FERGUSON of New York is engineer in charge of the erection of new pulp mills for the St. Maurice Paper Company near Three Rivers, Quebec. This is to include both sulphite and sulphate mills of considerable capacity.

WILLARD F. ROCKWELL, consulting engineer of Boston, Mass., has been commissioned to equip and organize a plant for manufacturing automobile parts. Unless a suitable location can be found and leased, it is expected that the new company will build a plant to be ready for occupancy not later than September 1. The location will be Cleveland, O., or vicinity.

FREDERICK C. MOORE has established an office at 710 Engineers Building, Cleveland, O., as consulting and executive engineer. He will act as consultant in all matters pertaining to factory or foundry operation, organization, production, equipment and accounting and costs, and will make special investigations and reports on new manufacturing projects and on the financial, commercial and physical condition of established concerns.

W. S. QUIGLEY corrects the statement in the June Journal that the Quigley Furnace Specialties Company, Inc., New York, recently organized, is a successor to the Quigley Furnace and Foundry Company. The Quigley Furnace and Foundry Company is still operating under the name of the Metals Production Equipment Company. Mr. Quigley is president of the new corporation, which comprises two departments, the furnace specialties department and the engineering and contracting department.

APPOINTMENTS

FRED. H. HEHEMANN, formerly mechanical draftsman of The Lunkenheimer Company, Cincinnati, O., has been appointed chief draftsman of the company.

ALBERT E. CLUETT, member of the firm of Cluett, Peabody and Company of Troy, N. Y., has been made chairman of the recently organized harbor and dock commission of that city.

EDWIN S. PEARCE, special engineer of the Cleveland, Cincinnati, Chicago and St. Louis Railway at Indianapolis, Ind., has been appointed assistant mechanical engineer with headquarters at Beech Grove, Ind.

HENRY A. STRINGFELLOW, consulting engineer of Rochester, N. Y., has been made consulting engineer for the Sedgwick Machine Works of New York. He will work on the design and construction of elevators and hoisting machinery.

GEORGE H. CUNNINGHAM, superintendent of construction for the Zinc Electrolytic Plants, Washoe Reduction Works, Anaconda, Mont., has recently been appointed construction engineer in charge of the installation of equipment in the new 100-ton zinc plant which the Anaconda Copper Mining Company is building at Great Falls, Mont.

AUTHORS OF PAPERS, ETC.

ROY A. SEATON is the author of a book, recently issued, on Concrete Construction for Rural Communities.

C. H. BIERBAUM has contributed an article on Graphite as a Lubricant to the June number of *Machinery*.

An article on The Action of Air in Surface Condensers by PAUL A. BANCEL appears in the June 13 number of *Power*.

ARTHUR J. WOOD is the author of a book recently published entitled Principles of Locomotive Operation and Train Control.

LEROY A. QUAYLE has contributed an article on Performances of Uniflow Engine and Turbine Compared to the June 6 issue of *Power*.

JOHN AIREY has contributed an article on Autographic Cross-Sectioning by a New Instrument to the June 8 issue of *Engineering News*.

Determining the Capacity of Compressors is the subject of an article by PAUL DISERENS, which appears in the June 15 issue of *The Iron Age*.

R. F. POHLE is the author of an article entitled Jig and Fixture Details—Clamps and Straps, which appears in the June issue of *Machinery*.

WILLIAM P. KENNEDY has contributed an article entitled Central Station Promotion of Electric Vehicle Use to the June 1 issue of *The Commercial Vehicle*.

DEXTER S. KIMBALL is the author of an article on Finding the Financial Basis of Special Tools which appears in the June 1 number of the *American Machinist*.

W. DEWITT VOSBURY has contributed a paper on Conservation of Operating Head Controls Design of Oaklyn (N. J.) Sewage Plant to the June 17 issue of *Engineering Record*.

J. S. UNGER presented a paper on Effect of Sulphur in Steel at the June 19-20 convention of the Boiler Manufacturers' Association of the United States and Canada, held in Cleveland, O.

EDWARD C. WORDEN presented a paper on Recent Developments in the Production of Nitrocellulose at the June 14 to 17 convention of the American Institute of Chemical Engineers, held in Cleveland, O.

DABNEY H. MAURY presented a paper on Waterworks Reservoirs at the June 7 meeting of the American Water-Works Association. An abstract of this paper appears in the June 15 issue of *The Canadian Engineer*.

The Distribution of the Charge Column and of the Ascending Gas Column, is the subject of an illustrated article contributed by J. E. JOHNSON, JR., to the June 1 issue of *Metallurgical and Chemical Engineering*.

NECROLOGY

ALPHONSO H. CARPENTER

Alphonso H. Carpenter was born at Ludlow, Vermont, on October 22, 1850. He received his education in the ordinary home schools and at the age of 14 went to work for Helon M. Carpenter of Grafton, Vermont, as a blacksmith, remaining there until he was twenty. The rest of his life was spent in the machinery manufacturing and foundry business as commercial traveler and manager. At the time of his death he was vice-president of the Acme Machinery Company of Cleveland, Ohio, which position he had held for many years.

Mr. Carpenter was elected to membership in the Society in 1895.

JACQUES HENRI EDWARDS

Jacques Henri Edwards was born in Paris, France on February 11, 1889. He was graduated from the University of Paris in 1909 with the degree of B.S. During the following year he worked as sales and technical man with the firm of Jean Horowitz in Paris, exporting automobiles, steam trucks and herringbone gears to Russia. From there he accepted a position with the American Tobacco Company in Montreal for the purpose of improving his knowledge of the English language and business methods. He also worked in Detroit with the Zenith Carburetor Company as assistant manager and also for the Studebaker Corporation and the Northway Motor & Mfg. Company and was a member of the firm of Breeze & Chapman, carburetor makers of Detroit. In October, 1913,

he went to St. Louis on special efficiency work and in June, 1914, entered the employ of Stanley G. Flagg & Co., who sent him to London and Paris as sales engineer, which position he held at the time of his death which occurred in Paris on February 24, 1916.

Mr. Edwards was a member of the Automobile Association of America. He became a member of this Society in 1913.

WILLIAM LAING BUSS

William Laing Buss was born at Correy, Pa., on November 26, 1867, and died on May 3, 1916. He received his early education in the public and high schools of Troy, N. Y., following which he engaged in the drug business. In 1888, he moved to Chicago and entered the Rush Medical College, but at the end of two years he left to go into business with his father who was western manager for the Chapman Valve Company of Springfield, Mass.

Upon the death of his father in 1903, Mr. Buss succeeded him as manager and remained there until 1909. From 1910 to 1912 he was general manager of the Coffin Valve Company of Neponset, Mass. From there he returned to Chicago to accept a position as sales manager for the Pittsburgh Valve, Foundry and Construction Company of Pittsburgh, Pa., and remained with them until 1915. At the time of his death he was a manufacturers' broker with offices in Chicago.

Mr. Buss was a member of several Masonic lodges. He became a member of the Society in 1912.

GEORGE GILMOUR

George Gilmour was born at St. Petersburg, Russia, on December 25, 1864. He received his preparatory education in the public schools of Russia and England and his technical education at Anderson College, Glasgow, Scotland. He learned his trade as mechanical engineer with John Elder and Company, shipbuilders and engineers, of Glasgow, Scotland, and was subsequently sent by them as an engineer to South America. On his return by way of Panama, he was engaged by the French engineers to take charge of the mechanical department of the work on the Panama Canal, 1883, and he afterwards held a position with the Atlas Line of mail steamers.

When the West India Improvements Company bought the Jamaica Government Railway, Mr. Gilmour was appointed master mechanic of the Jamaican system, 1891, and he later became superintendent of motive power, and consulting engineer to the Jamaica Light and Power Company.

After eight years of service in Jamaica, Mr. Gilmour was appointed mechanical engineer to the New York Telephone Company, of New York City; and after eight years of experience in this capacity, he resigned in 1905 to become chief engineer of the Travelers Insurance Company, which position he held at the time of his death. In 1910, the New York Commission on Employers' Liability and Causes of Industrial Accidents appointed him its consulting engineer and in that capacity he made an extended tour abroad to investigate and report upon the European methods for lessening the number of industrial accidents.

Mr. Gilmour was a charter member and trustee of the American Museum of Safety, and he was also a member of the American Railway Master Mechanics Association, the International Boiler Makers Association, the American Society for Testing Materials, and the Engineers' Club of New York. He became a member of this Society in 1909. Mr. Gilmour died at his home in Brooklyn on June 15, 1916.

SOCIETY MEETINGS

IT is of the highest importance in the development of the monthly meetings of the Society, both of the Sections and of the Student Branches, that comprehensive reports of these meetings be published in The Journal regularly. Secretaries of the sections and student branches are urged to make every effort to get the complete reports of their meetings to this office as quickly as possible after the meetings are held, and also where possible, copies of the papers presented should be sent in; if desired, the copy of the paper will be returned after examination. The reports of meetings in order to appear in the next issue of The Journal must be received in this office before the 18th of the month.

CHICAGO, MAY 15

The fourth and last seasonal meeting of the Chicago Section of the Society was held on May 15. Following the dinner, H. M. Montgomery, *chairman* of the Section read the report of the nominating committee for the officers of the Section for next year, as follows: Joseph Harrington, advisory combustion engineer, *chairman;* Alexander D. Bailey, assistant chief engineer, Station 2 and 3, Commonwealth Edison Company, vice-chairman; Robert E. Thayer, western mechanical editor, Railway Age Gazette, secretary; other committee members. H. T. Bentley, superintendent motive power and machinery, Chicago & North Western, and Charles G. Lord, general patent attorney, International Harvester Company. The report was approved by the attending members. The meeting was attended by 191 members and guests, among the latter being included a representative body from the International Railway Fuel Association, which was meeting in convention at Chicago at that time.

After the dinner the speaker of the evening, Joseph Harrington, advisory combustion engineer, of Chicago, was introduced and presented a paper on Powdered Coal as a Fuel. The speaker reviewed the history of the use of powdered fuel, summarized the requirements for pulverization, described types of pulverizing machinery, discussed the objections to and difficulties of pulverization and enumerated the advantages. He followed with examples of some of the results being obtained in stationary and locomotive practice.

The paper was illustrated by a series of slides showing furnaces in which powdered coal is used as a fuel.

Among those who took part in the discussion which followed were J. E. Muhlfeld, president of the Locomotive Pulverized Fuel Company; A. G. Barnhurst of the Fuller Engineering Company; W. L. Robinson, of the Baltimore & Ohio; E. H. Stroud, A. J. Kinyon and others. Mr. Barnhurst presented a written discussion describing the pulverized fuel installation under ten 250-h.p. Heine boilers for the Missouri, Kansas & Texas Railway at Parsons, Kan.

Mr. Muhlfeld explained briefly the development of the use

of pulverized coal on locomotives. The use of pulverized coal in this service permits the using of cheaper grades of fuel with almost perfect combustion. There were five different methods developed for burning pulverized fuel in locomotives, and the one now in use on the Chicago & North Western locomotives was finally adopted. The bituminous coal installations have been working out very satisfactorily and experiments are being tried with a mixture of anthracite and bituminous coal. So far 40 per cent anthracite and 60 per cent bituminous coal has been used successfully, and it is believed that it will be possible on further experimentation to use a mixture of 80 per cent anthracite and 20 per cent bituminous. In stationary practice 100 per cent anthracite is used successfully.

Regarding the accumulation of slag in the powdered fuel installations, it was believed that those coals running high in iron content would give the greatest trouble. It is necessary that sufficient air be supplied to put what iron there is in coal into its ferric state. The illustrations shown by Mr. Harrington on the screen showed the very interesting and novel ways of getting away from this trouble of slag. The fusibility of the ash in the coal is also a factor to be considered. It was stated that lime had been added to the powdered fuel to assist in fluxing the slag so that it would flow more freely to the slag pan.

CINCINNATI, MAY 18

A meeting of the Cincinnati Section of the Society at which there was a special program for the entertainment of the ladies was held on May 18. The speaker of the evening was Prof. John M. Burnham, Professor of Latin at the University of Cincinnati, who gave an illustrated address on Engineering in Antiquity. An abstract of his remarks is given here:

Engineering may be said to have begun when early man made any sort of implement or weapon, however crude or simple and the engineer, at least the artisan, the skilful worker was recognized as early as the Neolithic Period (say from 7000 to 4000 years ago).

A high state of development is implied by the Famous Seven Wonders of the World, most in the Classical Greek domain, and in the Pyramids and the Hanging Gardens and Walls of Babylon, going back further in time and more distant in space. One must also remember that the peoples of Assyria, Babylon, Mesopotamia, Syria, Asia Minor and Egypt had elaborate systems of drainage and irrigation without which comfortable life, sanitation and agriculture would have been impossible; they also had canals and ditches on a large scale both to serve internal navigation and to connect large bodies of water. For instance, Ferdinand de Lesseps while cutting the Suez Canal found the traces of two similar projects ranging back several centuries B. C. The cutting around Mt. Athos by Xerxes and the running of tunnels at Jerusalem are samples of the same sort of activity; even the myth of the cleansing of the Augean Stables implies such work as a part of the very ancient Greek life.

Rome, too, had her system of engineering. There were drainage and irrigation ditches all the way from the Trasemene to the Fucine Lake. Scaurus in 110 B.C. rehabilitated the work of the Etruscans in the Po Region which must at the latest antedated 400 B. C. Dentatus in 300 B. C. turned a river bed and directed its new course over a precipice 140 ft. high. There was the Alban tunnel which was 1100 ft. long and also fossae, connecting ditches or canals uniting for instance the Meuse and the Rhine or the Rhone and the Mediterranean Sea which were built in the early years of A. D. Caesar revived an early project conceived by Periander undertaken and then abandoned by Demetrius Poliorcetes, but his death prevented the completion of this and other schemes. Caligula again took it up, fixed its lines and levels, and passed it on to Nero who actually began it but death once more intervened in 68 A. D.

One may refer to the mighty network of pikes and highways which began at Rome and crossed and recrossed the Italian Peninsula. These were connected at the Northern, Eastern and Western boundaries with similar roads reaching into Thrace to Constantinople, there meeting the Asiatic system which extended into Northern and Central Europe, modern Switzerland and Austria, into France and reaching the English Channel. They were also to be found in Southern England and Spain. Besides these pikes and highways there were the great aqueducts, which according to one text numbered 19. There were also numerous bridges spanning the Tiber and many another river, the innumerable colonnades of ancient Rome (nine miles of them, according to Lanciani), 67 parks of the Capital and 46,000 tenement houses.

The social standing of the engineer is stated by Cicero de Officiis 1 150 to have been that of the teachers and physicians . . . . good enough for people who adopted such a career. However, the engineer Frontinus to whom we owe most of our information about the water supply of Rome rose to the consulate i. e. was an aristocrat. In fact, under the Empire, certain engineering superintendencies required training and were granted only to those who had held the highest political stations. As for their education, Vitruvius demands an almost encyclopedic knowledge of the architect; drawing, geometry, history, philosophy music, medicine, law and astronomy (including meteorology).

CHICAGO, MAY 24

A special meeting of the Chicago Section of the Society was called on May 24 at the Chicago Engineers' Club to meet with President Jacobus and to talk over Society affairs. Dr. Jacobus presented some slides showing views of the Engineering Societies Building in New York, and also balance sheets indicating the financial condition of the Society. He asked for and obtained opinions of the members regarding the yearly Condensed Catalogues, the advisability of distributing the papers to be presented at the various meetings of the Society in advance of the meetings, and The Journal.

PROVIDENCE, MAY 24

The first meeting of the Providence Engineering Society which is the successor to the Providence Association of Mechanical Engineers was held on May 24. William Pickersgill, designing engineer of the Providence Water Supply Board, addressed the Society on The Fiskeville Weir which is being used in connection with the new water supply system of Providence. His talk was illustrated with charts and also with an experimental weir in the University of Brown laboratory.

Following Mr. Pickersgill, Prof. A. E. Watson of Brown University spoke on The New Wireless Installation at Brown. Following his remarks the engineers were invited to the electrical laboratory and were shown the workings of the new instruments.

BIRMINGHAM, MAY 30

A meeting of the Birmingham Section of the Society was held on May 30 at which pictures showing From Ore to Finished Product were shown by the National Tube Company. The pictures were explained by Mr. Schoekel from Atlanta, Ga.

Following the presentation of the pictures, an informal meeting was held by several interested in forming an affiliated society in Birmingham. Committees were appointed to report on the matter and the local Section of the Am.Soc.M.E. pledged its support.

LOS ANGELES, JUNE 1

A joint meeting of the Technical Societies of Los Angeles including The American Society of Mechanical Engineers, the American Chemical Society, The Engineers and Architects Association, the American Institute of Electrical Engineers, the American Institute of Mining Engineers and the American Society of Civil Engineers was held on June 1. The speakers were George N. Davidson, rector of St. John's Church, Earle Remington, president of the Aeronautical Society, Capt. Charles T. Leeds, U. S. Army (retired), Major George B. Pillsbury, in charge of the Fortifications, San Pedro, George W. Dickie, of the California Auxiliary Naval Consulting Board and Willis H. Booth, vice-president of the Security National Bank. An account of this meeting appears elsewhere in this issue.

CINCINNATI, JUNE 15

The June meeting of the Cincinnati Section which was a joint meeting with the Engineers' Club of Cincinnati was held on June 15. The speaker of the evening was Major P. S. Bond, Corps of Engineers, U. S. A. Major Bond is an Honor Graduate, Army Field Engineer College; a graduate of the Army Staff College; author of The Engineer in War; and the author of National Defense for Engineer and Contractor.

The speaker set forth in a clear cut and convincing manner the duty each citizen owes to his country. He alluded to the woeful inadequacy of our defenses and gave in detail the requirements of the men of every grade in the engineer corps, with an estimate of the length of time necessary to give such men the necessary training in tactics and in technics. He discouraged the rather hysterical forms of patriotism and urged the solution of the whole problem of our preparedness for offense and defense in a calm and intelligent manner. He stated that the details that are being so eagerly sought by the general public at this time regarding the state of our preparedness had been a matter of common knowledge among engineer officers for many years and that it was only recently that the general public could be induced to take any interest in them whatever.

Major Bond gave in detail the tremendous possibilities for defense which exist in this country, both in numbers of men available and in the ability of our country to turn out needed supplies and munitions at the proper rate. He cited an instance from one of the warring nations of Europe where a large factory concluded its work upon a given order at eleven o'clock of a certain morning and began the manufacture of rifles in an efficient manner at two o'clock of the same day.

Mr. Bond then outlined the general plans that had been proposed for surveys of our industries looking toward the supplying of the necessary materials and munitions in case of war, and showed how necessary it was to prepare for the manufacture of these supplies of munitions in time of peace. He declared that so large a time is required to prepare for the manufacture of materials and munitions in enormous quantities that months and frequently years of time had elapsed before a reasonable efficiency could be obtained in the manufacture of supplies and munitions. The fate of a war, he stated, might be decided before a reasonable efficiency had been obtained by a factory that had not carefully analyzed the problems that it would have to meet after the declaration of war. The speaker stated that in numbers of men and ability to furnish supplies and munitions, our country was so far ahead of any nation that the mere knowledge of the fact that our resources in these lines were being made directly available for immediate service in case of necessity would almost certainly insure peace.

The lecture was concluded by an exhibition of a large number of carefully selected lantern slides and a running commentary on the details shown by these showed the duties of the members of the Engineer Corps in the field. The slides were taken from actual service conditions in Mexico, the Philippine Islands and the European war. They showed the construction of bridges, the making of military roads, the making of trenches, the theory of trench warfare, the character and purpose of the various kinds of guns in use at the present time, the various styles of clothing and of implements that are required for the soldier in the trenches, some idea of the difficulties encountered in transportation and in feeding large numbers of men, and of the enormous amount of supplies and munitions required. The speaker touched upon a multitude of facts, driving home the points they were intended to emphasize in clear and forceful language and withal presented the subject in a wonderfully interesting manner.

At the conclusion of the meeting, a motion was unamiously carried that a committee of five be appointed with power to act in the matter of a survey of the industries that would be called upon to manufacture supplies and munitions in case of war. This committee is to secure the services of twenty-five or thirty engineers to make industrial surveys of Cincinnati and vicinity and assist the committees on industrial preparedness that were recently appointed by President Wilson.

STUDENT BRANCHES

BUCKNELL UNIVERSITY

The Bucknell University Student Branch of the Am. Soc. M. E. held its last meeting of the school year on June 5. After a short business session, the election of officers for the ensuing year took place. The officers elected were as follows: C. D. Maurer, '17, chairman; C. C. Kepple, '17, vice-chairman; C. M. Kriner, '17, secretary, and R. E. Sprenkle, '17, treasurer.

COLUMBIA UNIVERSITY

The following officers were elected at the annual meeting of the Student Branch of Columbia University on May 16: J. L. Kretzmer, president; William Henry, vice-president; Edward H. Shea, treasurer, and Ray W. Thompson, secretary.

CORNELL UNIVERSITY

The new officers chosen for the Cornell University Student Branch are as follows: Prof R. C. Carpenter, honorary chairman; William Carter Bliss, chairman; Ralph Osgood Compton, vice-president; Samuel Max Barr, recording secretary; William Wallace Robertson, Jr., treasurer, and Charles Edwin Thomas, corresponding secretary.

During the past year several meetings of the Branch have been held and all have been well attended. Lectures have been given before the Branch by Prof. Albert W. Smith on The Advantages of Engineering Organizations: by Prof. D. S. Kimball on Efficiency; and by Prof. R. C. Carpenter on The Panama Canal.

LOUISIANA STATE UNIVERSITY

A meeting of the Louisiana State University Student Branch was held on April 11, and the following officers were chosen: T. S. Gunby, chairman; S. A. Buckmaster, vice-chair-

man; J. A. Nadler, secretary, and R. E. H. Blomley, treasurer.

Following the election of officers, Mr. Spence gave a talk on the Westinghouse Air Brake.

A special meeting of the Branch was held on April 18. At this meeting C. C. Allen, construction engineer of Stone and Webster Corporation, gave a very interesting and practical lecture to the students in engineering. He urged the students to take a four years apprenticeship in some good shop, and laid especial stress upon the value of practical experience.

The third regular meeting was held on May 2, at which Maurice Adam addressed the Branch on the Adaptability of the Internal Combustion Engine to Sugar Factories in the Tropics and States, and M. M. Masson gave a brief discussion of the Spring Meeting of the Society at New Orleans.

OHIO STATE UNIVEFSITY

The last meeting of the year of the Student Branch of Ohio State University was held on May 13, and was in the form of a banquet, following which there was a discussion of the recent eastern trip taken by the engineering students with Professors Marquis, Judd and Brown.

The officers for the coming year were chosen as follows: Fred W. Kelly, president; I. F. Rehn, vice-president; G. W. Geisinger, secretary; V. N. Braden, treasurer, and Cecil McGuiley, sergeant-at-arms.

THE PENNSYLVANIA STATE COLLEGE

The following officers of the Student Branch of Pennsylvania State College were chosen at a meeting of the Branch on May 18: F. G. Bright, president; R. S. Smith, treasurer, and R. S. Clark, secretary.

V. D. Longo discussed Ingersoll-Rand Compressed Air Machinery. His talk was illustrated with slides.

PURDUE UNIVERSITY

The officers of Purdue University Student Branch were chosen at the meeting of the Branch held on May 9 and were as follows: L. C. McAnley, chairman; J. A. Pearce, vice-chairman; H. L. Covert, recording secretary; G. A. Ruess, corresponding secretary; A. B. Birtles, treasurer, and J. B. Madden and E. R. Wagstaff, governing council, and Prof. L. V. Ludy, faculty member of the governing council.

STATE UNIVERSITY OF IOWA

A meeting of the Student Branch of the State University of Iowa was held on June 6, at which the officers for the coming year were elected: O. H. Beyer, chairman; H. V. Swanson, vice-chairman; F. J. Konvalinka, secretary and treasurer, and a governing committee consisting of R. S. Wilbur, Rex Harrington and S. E. Gibbs.

UNIVERSITY OF CINCINNATI

At a meeting of the Student Branch of the University of Cincinnati on May 18, 1916, the following officers were elected: W. Cowell, president; L. De Quasie, vice-president, and E. A. Botts, secretary and treasurer.

R. Rickwood, student member, read an article on The Importance of English in Technical Education, written by Lytle Harrington, who is a consulting engineer and a member of the Executive Council of Tau Beta Pi.

C. Joerger, instructor in Mechanical Engineering, gave a short talk to the men, giving a number of excellent suggestions for the Student Branch.

UNIVERSITY OF COLORADO

At a meeting of the University of Colorado Student Branch held on May 11, Walter F. Mallory read a paper by Luther D. Burlingame on The Evolution of the Milling Machine—Its Place in History. The paper was illustrated with slides and followed the development of the milling machine from the earliest attempts at milling metal to the present universal milling machine.

EMPLOYMENT BULLETIN

THE Secretary considers it a special obligation and pleasant duty to make the office of the Society the medium for assisting members to secure positions, and is pleased to receive requests both for positions and for men. Copy for Bulletin must be in hand before the 18th of the month. The notices appear in the Employment Bulletin in a form which indicates the classification.

POSITIONS AVAILABLE

These advertisements are placed by members of the Society or persons vouched for by members. The Society is pleased to act as a "clearing house" but is not responsible for results.

In forwarding applications, stamps should be enclosed for transmittal of applications to advertisers; applications from non-members should be accompanied by a letter of reference or introduction from a member, such reference letter to be filed by the Society.

CADET ENGINEERS: Recent graduates of technical schools, for work in connection with studies of central station power house operation, in line of improving their operation and methods. Salary starts at $60 per month. Further advance entirely a matter of personal ability to fit into the organization. Location New Jersey.—37.

DRAFTSMAN, experienced in heavy machinery work and if possible on chemical apparatus. Salary $25-$30. Location New Jersey.—50.

ASSISTANT CHIEF ENGINEER, young man who has had experience, or special duty in the operation of a power plant, to assist in running a wood working factory of 1000 h.p. Knowledge of the design of exhaust steam heating on a large scale, a desirable asset. Answer, stating age, past position and salary expected.—83.

DRAFTSMAN, experienced in design of heavy machinery, rolling mills, etc. Location Connecticut.—98.

ASSOCIATE PROFESSOR IN EXPERIMENTAL MECHANICAL ENGINEERING in large engineering school in Atlanta, Ga., wanted next September. Must have recognized engineering degree and teaching experience or extensive practical experience in experimental and research work. Give full details of education, post-graduate work and practical experience, including references.—293.

SUPERINTENDENT for plant for wood chipping machinery, and processes for oxidizing. Location near New York.—319.

ASSISTANT SUPERINTENDENT in special charge of production work in large machine shop in Middle West, manufacturing locomotive and wrecking cranes. It is desired to harmonize present methods and supplement them with scientific management processes as far as possible. Experience along these lines preferred. Exceptionally fine opening for the right man.—338.

INSTRUCTOR IN ELEMENTARY STRENGTH OF MATERIALS MECHANICS, and to act as Assistant in electrical laboratory. Previous experience in teaching not necessary but two or three years in practice. Salary $1200 for school term. Location Pratt Institute, Brooklyn.—342.

FIRST CLASS AND EXPERIENCED MACHINE TOOL DESIGNER capable of laying out tooling and special fixtures for quantity production. Apply P. O. Box 428, Hazleton, Pa., stating experience and salary expected.—344.

SALES ENGINEER; a young mechanical engineer with three to five years experience in both shop and drafting room, preferably in automobile work, to train into sales work. Location Detroit. Write, giving full particulars of experience, education and references.—345.

SALESMAN, experience in conveying machinery preferred but not essential. Splendid territory with branch office and good position are offered to right man. Exceptional opportunity but only live, energetic, successful salesman with A-1 record will be considered. Replies treated absolutely confidential, but must give full particulars of experience, amount of sales, record, salary expected, references, etc. Apply through Society, name confidential.—346.

DRAFTSMAN, on multi-color press design. State experience, age and expected salary. Location Rahway, N. J.—349.

PRODUCTION ENGINEER of experience, with knowledge of conveying machinery, to take charge of constructing details. State fully age, experience, education, salary wanted, and when available. Position offers good prospects, but only man who can produce results will be considered. All correspondence confidential.—350.

HEATING and VENTILATING ENGINEER for position in Toronto, Canada (interview through New York office)—heating and ventilating systems, involves getting out of specifications design and supervision of installations. Technical graduate preferred.—358.

SALESMAN having experience in tool steel, alloyed steels preferred; opportunity for advancement. Applicant must state age, experience and salary expected. Location New York.—360.

SALESMAN with technical education to sell high grade recorders and efficiency instruments. State age, education, experience and salary desired to start.—362.

ASSISTANT wanted in September in mechanical laboratories in eastern technical school. Must have been out of college at least a year and had some practical experience in the care and handling of mechanical equipment. Give full details of education, practical experience and references. Location near New York.—366.

CLERK for order and traffic department. Experienced in iron and steel, particularly tool and alloy steels and specialties preferred. To receive attention state age, experience and wages expected. Location New York.—367.

DRAFTSMAN experienced on drawings of dies, jigs and fixtures for pressed and drawn metal work. State reference, experience, salary expected, etc. Location New England.—372.

DRAFTSMAN, familiar with the design of piping and the layout and equipment for power plants. State training, experience and salary expected. Location New England.—379.

CHIEF ENGINEER for Chemical Works, one experienced in Power Plants, capable of taking full charge. Present plant of 3000 h.p. boilers generating power for electro-chemical work. Applicant must be not less than thirty years of age; salary to start about $2400.—376.

MEN AVAILABLE

Only members of the Society are listed in the published notices. Notices are not repeated in consecutive issues of the Bulletin.

Members sending in notices for the Men Available section are particularly requested in the future to indicate the classification under which they desire their notices to appear.

SALES ENGINEER, MANAGER or MANUFACTURERS' REPRESENTATIVE Graduate in mechanical engineering, Worcester Polytechnic Institute; age 36. Thirteen years broad practical experience selling and managing sales in New York City, pumping machinery, air compressors and internal combustion engines with their auxiliary equipment. Good business record with leading concerns in these lines.—G-245.

MECHANICAL or CHIEF ENGINEER, age 31, four years experience as superintendent of erection and chief operating engineer of large power and industrial plants; four years in charge of design and detailing of power plants; good executive ability, capable of assuming any responsibility in power plant lines and getting results from factory organization. Location in U. S. A. preferred. Salary $2500.—G-246.

MECHANICAL ENGINEER and EXECUTIVE. Graduate Stevens Institute of Technology, member A.S.M.E., 35 years old, orderly minded, resourceful, energetic, desires position of larger executive responsibility and future so that the location may be a permanent one. In the following positions during the past eleven years—chief draftsman, production superintendent, mechanical superintendent, efficiency engineer. Present salary $3600 per year—G-247.

MEMBER, thirty-two, M. I. T., wishes position with an eastern manufacturing firm. Experienced in design and application of mechanical conveyors for the handling of materials; special machinery; six years office and sales experience. Apply through Society.—G-248.

DRAFTSMAN, SALES ENGINEER. Experience of 12 years. Working knowledge of steam engines, boilers, electricity, tools, etc. Conducted and compiled reports of tests. Only position with future considered. 32 years old. Technical education. Salary moderate; location immaterial.—G-249.

SALES ENGINEER, MANAGER or SUPERINTENDENT; age 35, 15 years experience in design, manufacture and sale of electrical machinery. A capable executive and organizer, thoroughly familiar with modern shop practice and well acquainted with trade, desires to communicate with manufacturer wishing services of a live and up-to-date executive. Assoc. Member A.S.M.E. Member A.I.E.E.—G-250.

PRODUCTION ENGINEER: 34, technical graduate, strong disciplinarian and successful handler of men, with organizing and executive ability, well versed in efficiency, rate setting, cost accounting and modern shop management, desires position along the lines of foundry, machine shop or sheet metal work. Compensation to be based on results.—G-251.

MECHANICAL ENGINEER, Columbia 1915, with good shop and drafting experience, seeks a position in or around New York City. At present employed.—G-252.

ASSISTANT ENGINEER or CHIEF DRAFTSMAN for one of the largest rubber manufacturing plants desires change. Technical graduate, ten years experience, five in above capacity. Would consider a position similar to that now held but prefers place where originality, organization or efficiency are required. Can make change in a reasonable length of time after engagement.—G-253.

MANAGER; mechanical engineering graduate; experience in machine shop and tool room, wishes a position in which training and experience will be necessities. Can furnish references.—G-254.

JUNIOR MEMBER, age 30, twelve years experience in patent practice, inventing, designing and developing automatic machinery; also executive in charge of manufacturing, factory and stock room system; wants opportunity to grow according to ability. Salary about $2500.—G-255.

FACTORY MANAGER or ASSISTANT TO EXECUTIVE of large corporation, ten years work in costs, statistics, efficiency engineering and factory management. Technical graduate, M.E. Experience in belting, office furniture and hardware lines. Uniformly successful in increasing output and decreasing costs. Desires permanent connection at a salary commensurate with training and ability.—G-256.

EXECUTIVE, ENGINEER or ASSISTANT, familiar with large and small construction, maintenance, operations, tests and inspections, competent to give or carry out orders, meet emergencies and to handle men. Location anywhere. Reply through the Society.—G-257.

TECHNICAL GRADUATE, 1911, E.E. and M.E., Junior Member, desires to make a change to position in the engineering department of company engaged in the design or construction of power plants or with a consulting engineer. Location in or near New York preferred.—G-258.

TEACHER in the Department of Mechanical Engineering or Physics in a technical school or university. Junior Member, E.E., M.E., Sc.D., with some commercial experience and five years teaching experience.—G-259.

ASSISTANT EXECUTIVE, large manufacturing corporation, in accounting or operating department, portion of duties to consist of increasing output and lowering costs through intensive management methods; age 31; technical graduate; past seven years in industrial management work, as employe of noted efficiency engineer, later connected with large corporation as special investigator and manager of plant. Seeking connection with company that is aggressive, successful and broad-policied. Initial salary secondary consideration.—G-260.

MECHANICAL ENGINEER, technical graduate in mechanical and electrical engineering, Junior Member, at present employed, desires to become identified with manufacturing or industrial plant in responsible position. Thirteen years varied experience in designing, constructing and operating steam and industrial plants; piping layouts, structural designs, thermal investigations of power plants, handling men, etc. An efficient executive now in charge of steam plants and of construction

work for large company. Prefers Eastern location or New York City. Salary to start $175-$200.—G-261.

ASSISTANT TO EXECUTIVE OR EXPERIMENTAL ENGINEER. Junior Member, 28, Stevens 1911 graduate, good experience in power plant, field and office. Last three years in successful executive and experimental work. Possesses initiative, good personality, unusual mathematical ability. Open for engagement with concern where energy and ability will win advancement.—G-262.

GRADUATE M.E. with engineering and commercial practice; familiar with modern methods of organization and the management of industrial corporations and manufacturing establishments. Experienced in the design, manufacture and sale of various products based on cost analyses; also in the increase of efficiency through sanitation safety provisions and proper recognition of the human element.—G-263.

CHIEF ENGINEER, Member, successful designer of automatic machinery, 2 years experience, desires charge of maintenance and operation of industrial plants. At present employed in executive position. Salary $4000.—G-264.

REPRESENTATIVE; engineer having own offices in Dayton, Ohio, desires to add additional representation for manufacturers in connection with his consulting practice. Will be glad to correspond with any manufacturer for that purpose.—G-265.

ACCESSIONS TO THE LIBRARY

A List of Books and Pamphlets Added During the Past Month to the Library of the Society and of the United Engineering Society, Engineering Societies Building, New York

ADDITIONS BY THE SOCIETY

AMERICAN WOOD PRESERVERS' ASSOCIATION. Report of Proceedings. 12th annual meeting. *Baltimore, 1916.* Gift of Association.

AUTOMOBILE IGNITION, STARTING, AND LIGHTING, Charles B. Hayward. *Chicago, American Technical Society, 1916.* Gift of Publishers.

This volume is written for the use of practical men, and therefore has much elementary matter. Its treatment of the subject is quite thorough. W. P. C.

DEVELOPMENT OF THE NEW BEDFORD WATER SUPPLIES. By R. C. P. Coggeshall. (Old Dartmouth Historical Sketches, no. 42.) *New Bedford, 1915.* Gift of A.S.M.E.

ELECTRICAL RAILWAYS. By H. M. Hobart. Being the "James Forrest" Lecture, 1915, delivered at the Institution of Civil Engineers. *London, 1915.* Gift of C. W. Rice.

ENGLISH AND AMERICAN TOOL BUILDERS. By Joseph Wickham Roe. New Haven, Yale University Press, 1916. Price $3.00. Gift of Publishers.

"Well informed persons are aware of the part which machinery in general has had on modern industrial life. But the profound influence which machine tools have had on that development is scarcely realized, even by tool builders themselves."

This opening sentence in Professor Roe's book indicates the object for which it has been written, to show in detail the history of the machine tool, and record the incidents in the lives of machine tool makers.

The book is one of peculiar interest to mechanical engineers, and is replete with information. W. P. C.

INDUSTRIAL LEADERSHIP. By H. L. Gantt. New Haven, Yale University Press, 1916. Price $1.00. Gift of Publishers.

Lectures given before the Senior Class at Sheffield Scientific School of Yale University in 1915.

The lectures, five in number, are devoted to the higher principles of scientific management, especially as to the importance of vocational training. W. P. C.

PUBLIC COTTON WAREHOUSES, GRAIN ELEVATOR AND TERMINAL OF THE BOARD OF COMMISSIONERS OF THE PORT OF NEW ORLEANS. May 1, 1916. Gift of New Orleans Public Cotton Warehouses.

SCHWEI. INGENIEUR UND ARCHITEKTENVEREIN. Jahresheft 1915 und Mitgliederverzeichnis. *Zurckh, 1916.* Gift of Schwei. Ingenieur und Architektenverein.

SCIENTIFIC MANAGEMENT AND LABOR, Robert Franklin Hoxie. *New York, D. Appleton & Co., 1915.* Gift of Publishers.

The United States Commission on Industrial Relations empowered the author to make an investigation on scientific management in its relations to labor.

In the present work, a critical examination is made of the claims of the proponents and opponents of scientific management, and, as is to be expected, the decision, so far as any decision has been indicated, is a compromise. W. P. C.

SECOND PAN AMERICAN SCIENTIFIC CONGRESS. The Final Act and Interpretative Commentary Thereon. *Washington, 1916.* Gift of Second Pan American Scientific Congress.

THE TECHNICAL PRODUCTION OF HYDROGEN AND ITS INDUSTRIAL APPLICATION, H. L. Barnitz. *New York, 1916.* Gift of author.

"WHAT IS AN ENGINEER?" "SCIENTIFIC RESEARCH IN AMERICA," A. A. Noyes. *Pasadena, 1915.* Gift of Throop College of Technology.

EXCHANGES

LIVERPOOL ENGINEERING SOCIETY. Transactions, vol. XXXVI. *Liverpool, 1915.*

SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS. Transactions, vol. XXIII, 1915. *New York, 1915.*

TRADE CATALOGUES

THE COLORADO CULVERT & FLUME CO. *Pueblo, Colo.* Catalogue 16-A. Metal Flumes and other irrigation supplies.

FLANNERY BOLT CO. *Pittsburgh, Pa.* Staybolts. *May, 1916.*

INTERNATIONAL MOTOR CO. *New York, N. Y.* Mack Motor Trucks. Model "AC," 3½, 5½, 7½ tons.

LEEDS & NORTHRUP CO. *Philadelphia, Pa.* Bulletin 875. Potentiometer system of pyrometry.

NEW LONDON SHIP & ENGINE CO. *Groton, Conn.* The Neseco News. *April, 1916.*

SHEPARD ELECTRIC CRANE & HOIST CO. *Montour Falls, N. Y.* Bulletin no. 60. Monorail hoist types.

TEXAS CO. *New York, N. Y.* Lubrication. *May, 1916.*

TRILL INDICATOR CO. *Corry, Pa.* The indicator book. *1916.* Gift of Geo. H. Gibson Co.

VALLEY IRON WORKS CO. *Appleton, Wis.* The Beater. *May-June, 1916.*

WALWORTH MFG. CO. *Boston, Mass.* Walworth Log. *May-June, 1916.*

WIEDEKE, GUSTAV & CO. *Dayton, Ohio.* Catalogue no. 48. Ideal Tube expanders; Ideal tube cutters. *1915.*

ADDITIONS BY THE UNITED ENGINEERING SOCIETY

DIE ABWASSER. IHRE BESEITIGUNG UND REINIGUNG, J. E. Mayer. *Leipzig, 1915.*

ADMINISTRATIVE REPORT OF THE STATE GEOLOGIST OF VIRGINIA GEOLOGICAL SURVEY, 1914-15. *Charlottesville, 1916.*

AEROPLANE. A CONCISE SCIENTIFIC STUDY, A. Fage. ed. 2. *London, 1915.*

AMERICAN ASSOCIATION OF UNIVERSITY PROFESSORS. Report of the Committee of Inquiry on Conditions at the University of Utah. *July, 1915.* Gift of Association.

AMERICAN MANUFACTURERS EXPORT ASSOCIATION. Year Book, 1915. *New York, 1915.* Gift of Association.

THE ANALYSIS OF PERMISSIBLE EXPLOSIVES. U. S. BUREAU OF MINES. Bulletin 96. *Washington, 1916.*

THE ANTHRACITE COAL FIELDS OF PENNSYLVANIA, AND THEIR EXHAUSTION. *Harrisburg, 1881.*

APPLETONS' NEW SPANISH-ENGLISH AND ENGLISH-SPANISH DICTIONARY, Arturo Cuyás. *New York, 1916.*

THE ATHENAEUM SUBJECT INDEX TO PERIODICALS, 1915. Science and Technology. *London, 1916.*

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BIBLIOGRAPHIE DER WÜNSCHELRUTE, Carl v. Klinckowstroem. *München, 1911.*

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CENTRIFUGAL FANS, J. H. Kinealy. *New York, 1905.*

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NEW CASTLE COUNTY HIGHWAYS, REPORT ON. Prepared for a special committee of the Chamber of Commerce, Wilmington, Delaware, Arthur H. Blanchard, H. G. Shirley and G. W. Tillson. *April, 1916.* Gift of Arthur H. Blanchard.

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OIL AND GAS MAP OF SOUTHWESTERN PENNSYLVANIA, 1915. *Harrisburg, 1916.*

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A collection of state reports, mining companies reports, and various pamphlets.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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ENGINEERING SURVEY

A Review of Engineering Publications in All Languages. All the leading periodicals of the engineering world, embracing over 1000 different publications, are received at the Library. These are systematically examined for review each month in the Survey.

SUBJECTS OF ABSTRACTS

ARRANGED IN THE ORDER OF THEIR APPEARANCE IN THE SURVEY.

AIR CRAFT BALLISTICS.
TERMINAL VELOCITY OF FALLING BODIES.
BALLISTIC COEFFICIENT.
CONCRETE AGGREGATES WITH LIMESTONE SCREENINGS.
ALLOYS, HEAT TREATMENT.
ALLOYS, STEEL AND COPPER COMPARED.
BALSA WOOD AS INSULATION MATERIAL.
PORTLAND CEMENT, CHEMICAL CONSTITUTION.
BAG-HOUSE.
STRAINERS, LOSS OF HEAD IN.
ORIFICES, LOSS OF HEAD IN.
SAND, LOSS OF HEAD IN.
OIL, FLOW THROUGH PIPES.
OIL, PHYSICAL CONSTANTS.
PRIME MOVERS IN THE OIL FIELD.
INTERNAL COMBUSTION ENGINE IN THE OIL FIELD.
STRICKLAND DOUBLE-ACTING FOUR-STROKE CYCLE ENGINE.
OIL ENGINES FOR PUMPING.
WIRE ROPE, LUBRICATION.
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STEEL, NEW HIGH-SPEED.
JIG AND FIXTURE STANDARDS.
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HOBLITT STEAMER SYSTEM.
WATER LEVEL INDICATORS FOR BOILERS.
FLOW OF HEAT IN METAL SHEETS.
FLOW OF HEAT IN METALS, INDICATING MATERIALS.
FLOW OF HEAT, SOLIDS TO AIR.
WATER IN COAL.

In nothing, perhaps, are the tendencies of modern engineering more evident than in the present methods of viewing materials of construction. Cement was cement to the engineer of yesterday, but the Geophysical Laboratory of the Carnegie Institution in Washington, as told by George A. Rankin in an abstract in this issue, has just carried out an extensive and thorough chemical and optical investigation of the constituent parts of portland cement, and discovered which of these constituents increase or decrease its strength and why, and incidentally shows how a better clinker can be ultimately produced. George H. Ruhling emphasizes the same idea in *The Michigan Technic* by maintaining that "it will always pay to screen aggregates and find out the proper combination whereby the densest concrete may be had." This is particularly significant, as not so long ago American engineering was accused of being excessively conducted along cut-and-try methods. From present indications it is permissible to look forward into a not distant future to the day when the American engineer will, perhaps in a higher degree than his European colleague, know exactly why and how he achieves those results of which the high quality has been already almost universally acknowledged.

THIS MONTH'S ARTICLES

In the abstract on air craft ballistics the meaning of terminal velocity of bodies falling from a high altitude is fully explained.

A general discussion of the heat treatment of alloys is presented from a paper by L. Grenet in a French publication. Among other things it contains an interesting comparison between steel and copper alloys.

The thermal properties of balsa wood are discussed by R. C. Carpenter, Mem.Am.Soc.M.E., who also compares the coefficient of heat transmission in his own equation with the specific conductivity e of insulating materials of the Bureau of Standards.

The new bag-house at the Midvale Smelter is described by L. S. Austin.

From an English publication is abstracted a report on extensive tests on the relation of viscosity of oil to the rate of flow through pipes carried out at the National Physical Laboratory under the direction of Dr. R. T. Glazebrook. These tests have shown clearly that the ordinary laws of viscous flow hold so long as the velocity of flow is below critical velocity and that above that figure the flow becomes turbulent.

The use of internal combustion engines for pumping and in the oil field is discussed in two articles, the first by C. R. Knowles and the other by F. G. Rappoport. In the same section is given an illustrated description of the Strickland double-acting engine, which, while working on a four-stroke cycle, gives a power impulse every revolution in each cylinder.

A statement is taken from an English publication that a new steel has been invented in England which contains none of the usual rare metals and is still a high-speed tool-steel from every point of view.

Studies of instruments for measuring radiant energy are reported from a publication of the Bureau of Standards. Such instruments are becoming increasingly important partly because they may be used as pyrometers in certain lines, and also in connection with investigations of heating systems.

A brief abstract is given of a paper on spur-gearing, read by D. Adamson, Mem.Am.Soc.M.E., before the Institution of Mechanical Engineers. Among other things the writer mentions the case of a pair of machine cut bevel wheels transmitting 1500 h.p. with a pitch line velocity of 3000 ft. per minute.

The high precision of screws used in munition work prompted apparently an investigation by the National Physical Laboratory of England on errors of screws, in which is particularly emphasized the influence of an error in one of the fundamental elements of a screw thread on the other fundamental elements, and the maximum admissible error in any of the fundamental dimensions.

Aeronautics

AIR CRAFT BALLISTICS

The article treats primarily of methods for determining the successive stages in the ascent and descent of projectiles fired vertically, the application being primarily to firing against air craft; but as the article involves considerations applicable to other problems it is of general engineering interest.

The author gives two diagrams, one showing the vertical heights attained by projectiles as a function of their initial velocity, and another the striking velocity of falling bodies.

He emphasizes the fact that in the case of falling bodies air resistance introduces a complex disturbance, since acceleration in the rate of fall is restricted to the initial stages of travel where the force of gravity is greater than the resistance of the air; then a state of equilibrium is established and the body continues to move at a constant velocity known as *terminal velocity*. In fact, a falling body may attain its terminal velocity at a considerable height from the ground, and thereafter, instead of an increase of velocity, there will be a slight decrease, due to the increase of resistance as denser layers of air are traversed. The terminal velocity is a function of the ballistic coefficient C, which is to be determined experimentally and is in turn a function of the weight and design of the falling body. With $C = 1.0$ the earth is struck at a velocity of 188 ft. per second, no matter whether the dropping height be 2000 or 12,000 ft. (*Arms and Explosives*, vol. 24, no. 284, p. 67, May 1, 1916, 3 pp., 2 figs. *pe*).

Engineering Materials

LABORATORY TESTS ON CONCRETE AGGREGATES, George H. Ruhling

The author made tests to determine the physical properties of concrete aggregates. In his work in Seneca County, Ohio, he found it to be the opinion of many engineers in that locality that the screenings from limestone should not be used for fine aggregate in concrete because it was alleged that the screenings contained too much fine material. Hence, the local specifications stipulated that all fine aggregate should be not less than 50 per cent lake or clean bank sand, this stipulation being always a source of argument between the contractors and the engineer for the county.

The writer made a series of tests to determine the best aggregate and found that, in the first place, it will always pay to screen aggregates and find out the proper combination whereby the densest concrete may be had, and, second, that concrete of stone screenings, if properly proportioned and with the stone screenings well graded, will make just as strong and probably stronger concrete than ordinary lake sand (*The Michigan Technic*, vol. 29, no. 2, p. 114, May, 1916, 7 pp., 8 figs. *e*).

GENERAL CONSIDERATIONS ON HEAT TREATMENT OF ALLOYS, L. Grenet

The paper presents a general discussion on the heat treatment of alloys. Because of lack of space, only the conclusions can be presented here.

Within the limits of the present investigation, various types of steel may be considered as systems consisting of two independent components, a ferrous component (pure or nearly pure iron) and a carbide. The ferrous component is malleable and has the ability to resist tensile stresses; it endows with these properties the phases α and γ which contain a large proportion of it. The carbide component is hard and brittle and forms (almost entirely) the phase γ_1 or cementite. This component γ_1 affects probably the mechanical properties of steel through its dissemination through it and through contact action between it and the phases α and γ, which latter are alone malleable. The influence of the phase γ_1 or cementite is more direct in the matter of resistance to wear or scratching than in tensile stresses.

The copper alloys may be considered as being formed of a cuprous compound, which in the case of binary alloys is pure copper, and the alloying compound. The cuprous compound plays the same part as the ferrous compound in steels, and the alloying compound the part of the carbide in steel.

Steel has the peculiar property that all of its phases may or may not be magnetic and the rapid variations of magnetism as a function of temperature are usually accompanied by rapid variations of the law which connects the other properties of steel with temperature, but as long as the phase does not change these transformations are almost entirely reversible, and the temperature at which they occur does not have to be considered except for the purpose of heat treatment of steel.

From the point of view of heat treatment the only difference between steels and alloys which we have to bear in mind is that the phase α of steels is derived from the transformation of the solid phase γ, however small may be the carbon content, while the phase α of copper alloys can be derived from the transformation of a solid phase γ only when the proportion of the metal allied to copper is sufficiently large.

The hardening by tempering bound by the conditions of transformation of the solid phase γ into the solid phase α is observable up to the limit of pure iron, but not up to the limit of pure copper alloys. But in all cases where it is possible to carry through this transformation with a change of phase while in the solid state, the phenomenon of tempering of alloys is identical to that of tempering steels. The tempering of a solid metal which on cooling undergoes a transformation with a change of phase does not differ from the tempering in a chill mold of a melted alloy, except by the greater intensity of the effect of tempering and the ability to carry through this operation without simultaneous deformation of the piece.

The hardness of an alloy is determined by the "heat history" of the phases of which it is composed. (*Généralités sur les traitements thermiques des alliages*, L. Grenet, *Bulletin et Comptes rendus mensuels de la Société de l'Industrie Minérale*, October-December 1915, 81 pp., 21 figs. *etA*).

THE PROPERTIES OF BALSA WOOD, R. C. Carpenter

Balsa wood, which grows extensively in the Central American and northern South American states, is the lightest wood known, and has been used quite extensively for life preservers and fenders of life boats and rafts. It appears also that it has important insulation qualities for heat. Only the latter will be discussed here.

The Bureau of Standards, Washington, D. C., has determined the specific conductivity, e, of Balsa wood, and found it to vary from 0.394 to 0.403 B.t.u. per sq. ft. per in. of thickness per deg. fahr. of difference in temperature between the surfaces for untreated wood, and from 0.424 to 0.383 B.t.u. for treated wood. Table 1 gives the results of the writer's investigation of heat transmission by determining the quantity of ice which melted in boxes made of Balsa wood and

other materials under known differences of temperature measured inside and outside. The results were reduced to B.t.u.'s transmitted per sq. ft. of mean surface between the outside and inside surfaces of each box, per degree of difference of temperature of the air inside and outside, per hour of time, which correspond to the "coefficient" of heat transmission k in the equation

$$H = k\ (T - T')$$

in which T = the temperature of the air on the entering side and T' = the temperature of the air on the discharge side, while H = the heat transmitted. The coefficient, k, differs from the specific conductivity, c, of the Bureau of Standards as it is dependent on the surface as well as the conduction capacity for heat transmission.

The author discusses in detail the relation between the specific conductivity, c, of the Bureau of Standards and the coefficient of heat transmission, k, of the above equation, and derives the following equation from which the relations between k and c can be computed provided the values of a_1 and a_0 are known:

$$\frac{1}{k} = \frac{1}{a_1} + \frac{1}{a_0} + \frac{x}{c}$$

In this equation x = thickness of the insulating material, a_1 coefficient of surface flow entering the body, and a_0 coefficient of surface flow leaving the body. This equation applies only to a single thickness without air space. It may be applied also, with proper modifications, to other cases.

A table is given showing comparative values of the coefficient k obtained by computation and by test (melted ice in a zinc box inside a balsa box). As computed from the Bureau of Standards tests, it is 5.98, and 5.80 as determined by ice melting experiments in Sibley College. (*Proceedings of the American Society of Civil Engineers*, vol. 42, no. 5, p. 649, May, 1916, 31 pp., 16 figs. *de*).

TABLE 1—HEAT TRANSMISSION EXPERIMENTS IN SIBLEY COLLEGE

TESTS MADE BY MELTING ICE

No. of Test.	Thickness of wood, in inches.	British Thermal Units Per Square Foot Per Degree of Difference of Temperature of Air.		Kind of Material
		Per hour k.	Per 24 hrs. k¹.	
1	2	0.121	2.90	Balsa wood, treated.
2	2	0.120	2.89	Balsa wood, treated.
3	2	0.122	2.93	Balsa wood, untreated.
4	2	0.192	4.61	White pine.
5	2	0.102	2.45	Nonpareil cork, extra.
6	2	0.122	2.93	Balsa, single boards, treated.
7	2	0.121	2.90	Balsa, double boards, at right angles.
8	2	0.1194	2.67	Armstrong, XX-cork blocks.
9	3	0.191	2.18	Balsa wood, treated.
10	2	0.1194	2.87	Balsa wood, treated.
11	1	0.199	4.78	Balsa wood, treated.
..	1/16	0.660	15.82	Bare zinc, 1/16 in. thick.

k coefficient of heat transmission per degree Fahrenheit of difference of temperature of air near the sides, per square foot, per inch of thickness per hour.

k¹ 24 k.

PORTLAND CEMENT, George A. Rankin

Discussion of the basic conditions affecting the physical properties of portland cement; the discussion is partly historical and partly from the point of view of the chemical constitution of the material.

Portland cement is made up of a number of chemical compounds, of which there is but one which in itself possesses all the properties of a desirable portland cement. This compound, tricalcic silicate, makes up only about 35 per cent of an average portland cement. It would appear, therefore, that one method of increasing the strength and durability of portland cement would be to increase the percentage of tricalcic silicate.

Portland cement consists of three fundamental oxides, lime, alumina and silica, and the relatively small admixture of other oxides exerts at most a wholly secondary influence; indeed good portland cement can be made from the above three pure oxides in the proper proportions. While ordinary chemical methods enable us to ascertain the aggregate proportion of each oxide present, they yield no information as to the manner in which these oxides are combined with one another, in other words, as to the substances which actually are present in the clinker and are responsible for its characteristic properties. It is very important to know this because until we know what the substances actually are we cannot hope to improve the quality of the material except by cut-and-try methods.

At the same time cement clinker is a mixture of substances of very similar properties and is besides exceedingly fine grained, which renders quantitative determinations of the constituents quite difficult. The method of investigation adopted by the writer begins with the isolation and determination of all the possible compounds of lime, alumina and silica which one may expect to find in portland cement clinker; next he proceeds to establish their relations at high temperatures and to ascertain their optical characteristics, which constitute the most convenient and satisfactory criterion of the identity of the several substances.

The characteristic properties of the several solid substances containing only lime, alumina and silica which are likely to occur in portland cement have been determined at the Geophysical Laboratory of the Carnegie Institution in Washington in the course of an investigation of all compounds formed when any mixture of these oxides is heated to a high temperature. This investigation is facilitated by the fact that in American-made portland cements the relative proportions of these oxides vary only between comparatively narrow limits, lime 60 to 64, alumina 5 to 9, silica 19 to 25 per cent. The author describes in detail the apparatus and methods of experimentation used. It has been found that the data can be interpreted most readily if they are plotted in three dimensions; the concentration (composition) of each mixture is represented by a point within an equilateral triangle on the horizontal plane; the magnitude of the corresponding temperature by the distance above the plane. In this way a model was obtained with a series of surfaces representing the melting temperatures of all products obtained when any mixture of the three oxides is heated progressively to higher and higher temperatures. The model resembles a relief map of a mountainous region. Each mountain peak is the melting point of a pure component or of a pure compound. The mountain slopes represent the melting temperatures of a component or compound in ternary mixtures; the points where the rivers

in the valleys meet to form a lake are the lowest melting temperatures known as eutectic points.

The author gives a diagram from which can be seen the behavior of the crystalline substances separating from a melt composed only of the three fundamental oxides in such proportions as to produce a good portland cement. In the actual manufacture of portland cement the necessary compounds are formed by burning at a temperature much below that required for complete melting. If, however, the cement clinker is not perfectly burned there will be present besides the three compounds before mentioned two others, namely, CaO and the compound $5CaO.Al_2O_3$. It has been found possible to determine the characteristic optical properties of each of the compounds and to show their various crystals. Microscopic investigation of commercial portland cement clinker shows it to be made up largely (over 90 per cent) of the three compounds tricalcic silicate, dicalcic silicate and tricalcic aluminate. It would appear, therefore, that the value of portland cement as a cementing material when mixed with water is due largely to one or more of these compounds. The author investigates their formation when portland cement is burned. The rapidity with which the reactions go to completion is governed by the temperature and by the amount of the flux formed at that temperature, the melting temperature of the flux necessary for the production of the clinker being materially lowered by the presence of small amounts of impurities. The author worked out a table which gives the constituents of portland cement present between certain definite temperature intervals during the burning of the clinker. The table applies equally to commercial portland cement and cement made up of the three fundamental oxides only. The components of portland cement are lime, alumina and silica and its constituent substances are definite compounds of these oxides. If the raw material for pure cement is perfectly burned at a temperature of 1650 deg. cent., the clinker obtained will consist of the three compounds, dicalcic silicate, tricalcic silicate and tricalcic aluminate. In the actual manufacture of portland cement, however, the clinker is not always perfectly burned, that is, the raw materials are not always ground fine enough or heated to a sufficiently high temperature so that the chemical reactions are completed. With the present knowledge of the nature of the chemical reactions it is, however, possible to state which of the constituents will not be completely formed. When commercial clinker is not perfectly burned there is less tricalcic silicate and more dicalcic silicate, while lime will be present as an individual constituent, the exact percentage of the material depending upon how near to completion the reaction

$$(CaO + 2CaO.SiO_2 = 3\,CaO.SiO_2)$$

has been carried. The importance of this is evident in view of the influence of lime on the physical properties of portland cement. Only cements in which the lime is entirely combined are sound and of good strength.

From the experiments made it appears that of the three compounds which take part in the setting and hardening of portland cement, tricalcic silicate is the best cementing constituent and that it is the only one of the three which when mixed with water will set and harden within a reasonable time to form a mass comparable to portland cement in hardness and strength. The dicalcic silicate requires too long to set and harden in order to be in itself a valuable cementing material. The tricalcic aluminate sets and hardens rapidly but is rather soluble in water and is not particularly durable or strong. The author comes, therefore, to the conclusion that the compound tricalcic silicate is *the* essential constituent of portland cement, and the higher its percentage the better the cement.

When tricalcic silicate is mixed with water to form a mortar, a gelatinous material is formed, composed of hydrous lime and silica. Whether the lime and silica continue to be chemically combined or whether the gelatinous material is colloidal is still a matter of some uncertainty, although it would appear that this material is colloidal. The author tries to establish that gelatinous silica is the most essential constituent of a cement mortar, but confesses that it is only a speculation.

The average portland cement of today contains about 30 to 35 per cent tricalcic silicate, a proportion which closely approaches the maximum possible yield with the present percentage of flux. With the finer grinding of the raw materials, burning for a longer period and at an increased temperature, a higher percentage of tricalcic silicate may be obtained but only at a materially higher cost of production. The writer hopes, however, that a study of other systems may establish the economic possibility of producing a cement containing a high percentage of tricalcic silicate. He thinks that an insight might be gained by substituting some substance, such as Fe_2O_3, for Al_2O_3, and then investigating the equilibrium relations of the new system. He comes to the final conclusion that in order to determine the most economic process for producing tricalcic silicate in the higher percentages it will be necessary to study the rate of formation of this compound in a series of mixtures of various substances, this in turn necessitating the determination of the equilibrium relations of tricalcic silicate at high temperatures in such mixtures. (*Journal of The Franklin Institute*, vol. 181, no. 6, p. 747, June 1916, 38 pp., 16 figs. *etA*).

Firing

NEW BAG-HOUSE, L. S. Austin

Description of a new bag-house at the Midvale Smelter. The bag-house was designed to take out the dust from any five out of six furnaces at a time, before the gases pass to the stack, these five taking the air from a blower of 175 cu. ft. per revolution at 160 r.p.m. or, allowing for 5 per cent of slip, 26,600 cu. ft. per minute. The temperature of this air, entering the blower at 40 deg. fahr., would be 200 deg. fahr. at the top of the charge with a volume, because of expansion by one third, of 35,470 ft. Allowing for the other furnace and for a leakage through the furnace top covers as well as for additional air admitted to lower the temperature at the bag-house to 150 deg. fahr., a fan capacity of 60,000 cu. ft. was needed. The main mechanical features appear in Fig 1 showing position of inlet damper and air feeder. From the fan, gases enter the flue *A* by a 7-ft. pipe. The adjoining main chamber, which consists of the dust chamber *D* and the bag chamber *C*, is divided transversely into five compartments or bays; each bay has an admission and an exhaust pipe, both controlled by disc valves. By adjusting these valves, any bay may be shut off and an exhaust connection opened, thus collapsing the bags and so loosening the flue dust that has accumulated on them. The exhaust pipe is branched into the exhaust main *X*, this leading back to the "trail" on the exhaust side of the fan. Once during a shift the valves are operated and after each shake a five-minute interval is allowed in order to give the dust an opportunity to fall into the lower chamber. Once in several days the bags are given a "hand-shake" to clean them more thoroughly.

The bottom of the dust chamber is inclined at 50 deg. When the bag-house was started, these grades were much flatter and the dust was expected to form its own slope, but it tended to arch over the feed screw and harden there so that the steeper slope of sheet steel had to be used.

As the gases seep through the bags they flow along the flue *D* which continues at a grade of nearly 5 in. per foot to the base of a brick-lined stack 210 ft. high by 16½ ft. inside diameter. In the flue *D*, deflectors are placed to turn the gases leaving the dust chamber into the direction of the flow. The velocity of the gases here is 9 ft. per second, while at the stack the flow is nearly 5 ft. per second.

The cost of the bag-house was $200,000, not including the stack (*Mining and Scientific Press*, vol. 112, no. 21, p. 746, May 20, 1916, 3 pp., 3 figs. *d*).

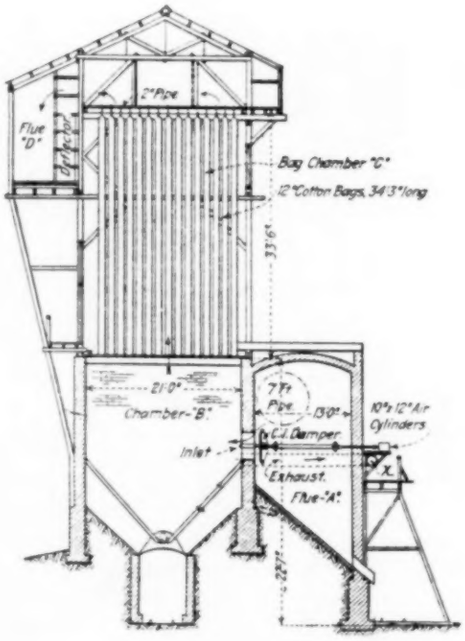

FIG. 1 SECTION OF BAGHOUSE SHOWING POSITION OF INLET DAMPER AND AIR FEEDER

Hydraulics

TESTS OF LOSS OF HEAD IN STRAINERS, ORIFICES AND SAND, Langdon Pearse

The data given in the paper are derived from experiments made by W. W. DeBerard and the author in 1908 during filtration investigations for the Peoples Water Company of Oakland, California. The article describes in detail the testing device used and the methods of operation. The tests were made with the orifices or strainers submerged. The data are presented in the form of tables and curves.

The tests of orifices indicate a coefficient of discharge ranging from 0.62 to 0.85 as a function of the ratio d/t, where d = diameter of orifices and t = thickness of plate. With a very few exceptions the coefficient of discharge C varied but little for the range of head tried on any one orifice. Similar tests were made for loss of head in strainers and sand and fairly consistent results were obtained for the coefficients of discharge for each type. (*Journal of the American Water Works Association*, vol. 3, no. 2, p. 504, June 1916, 11 pp., 7 figs. *e*).

THE VISCOSITY OF OILS IN RELATION TO THE RATE OF FLOW THROUGH PIPES, Dr. R. T. Glazebrook, W. F. Higgins, and J. R. Pannell

The paper presents data of tests undertaken by the National Physical Laboratory at the request of the British Admiralty. The object of these tests was to investigate the loss of flow of oil in drawn steel pipes of varying sizes with a view to determining how far the pressure difference required to produce a given flow could be calculated from a knowledge of the dimensions of the pipe and of the viscosity of the oil. The experiments were made on the flow of four oils in pipes of 3, 4 and 5 in. diameter.

Further tests were made for the purpose of determining the densities and viscosities of the oils used at various temperatures and the measurement of their flash points. Tests were also made on mixtures of various oils, with special regard to the permanence of the mixtures. Among other things it has been found that Mexican oil is apparently subject to a change in viscosity with time: the viscosity increases if the oil is kept at a low temperature, but is reduced again by short exposure to high temperature.

As regards the loss of flow it was found that the ordinary loss of viscous flow held so long as the velocity of flow was less than the critical velocity which is given by the equation

$$\frac{\rho V d}{\eta_i} = 2500$$

where V is the velocity of flow in feet per second, d = the diameter of the pipe in feet, ρ = the density in pounds per cu. ft., η_i = the viscosity coefficient, in foot-pound-second units. It has been found that in all such cases the flow is stream-line in character and the pressure drop is given by

$$\frac{P}{V} = \frac{2\rho}{g d^2}\left((AT - \frac{B}{T}\right)$$

where P is the pressure-difference in lb. per sq. in. and per ft. run, and g is the acceleration due to gravity in feet-second units. A and B are constants of instruments given by special equations in the original articles, and T is the time of flow in seconds observed in the viscosimeter experiments, at temperature t.

For values of velocity greater than 2500 ft. per second the flow is turbulent and the known relation for turbulent flow can be applied when the condition of surface roughness of the pipe is known.

In the discussion which followed one of the speakers pointed out that the experiments were made with a drawn pipe and that the presence of joints which usually occur at distances of 20 or 30 ft. apart, might materially affect the results.

The second part of the investigation, covering the physical constants of the oil, is of great interest, but cannot be abstracted because of lack of space. In an appendix is described the manometer used in the experiments. It is a modification of the pressure gage as designed by Dr. A. P. Chattock. (*Journal of the Institution of Petroleum Technologists and Record of Transactions*, vol. 2, part 5, p. 45, December, 1915, 38 pp., 14 figs. *eA*).

Internal Combustion Engineering

THE INTERNAL COMBUSTION ENGINE IN THE OIL FIELD, F. G. Rappoport

Discussion of various sources of power to be used in oil fields.

The author compares oil fired internal combustion engines with gas engines, steam power and electricity in their application to oil fields. The paper is written on the basis of practice in the Caucasian oil fields, Russia.

Besides its ready adaptation to a piecemeal system of development, the great advantage of steam power is its elasticity and flexibility in readily and quickly responding to the intermittent power requirements for which the character of oil field work calls. In boring, changes of speed are constantly required at short notice. In baling, likewise, a constantly changing speed is required. On the other hand, steam power is inefficient and uneconomical.

Electric power has the important advantage of the economies of the central power station with an efficient steam plant, high pressure steam, etc. In the application of the power, however, the constant-speed electric motor lacks the flexibility of the steam engine. Further, it can be applied only to well-established fields or fields which are very conveniently located to existing plants.

The crude oil engine, especially of the medium compression type, has the following advantages: (1) Minimum fuel consumption per unit of power; (2) can be installed in all stages of oil field development on a large or small scale; (3) occupies a minimum of space in proportion to the power developed; and (4) is clean and safe and, with good supervision, comparatively cheap to maintain. The disadvantage of the present method of using oil engines on a large scale in the oil field is, in the first place, the decentralization of the power plant. The plant is installed in separate scattered units at each well, which means increased danger from fire, increased supervision and labor. The total power laid down must be equal to the maximum power and the reduction effected in centralized plants by equalization of peak loads is unobtainable.

The chief practical difficulty in the use of oil motors on oil fields is their constant speed. For example, in drilling, the regulation of the number of blows per minute is important in rock of varying hardness. The freeing of a column of casing which has become fast may require momentary increase of power applied without delay, and the oil engine cannot provide that instantaneous variation of speed necessary in such cases.

In the Baku fields an attempt is made to return to centralization by using one high-power engine to drive several wells, and this principle is being still further extended by the use of wire rope transmission to cover long distances. The author shows diagrammatically the advantage of such centralization. One 150-h.p. motor centralized is sufficient to drive four wells, whereas by installing a motor on each well about 200 h.p. would have been needed.

The oil engine, however, has created a large and important sphere of its own by facilitating profitable operation of a large class of wells which, owing to their small yield, could not have been profitably exploited by either steam or electricity.

The next form of internal combustion engine is that utilizing gas, natural and artificial. The gas engine is simpler in construction, cheaper, and possesses greater flexibility. A drawback to its extended use is the uncertainty of the supply of gas.

The author describes and classifies modified types of what is known as convertible engines, i.e., those which can be alternately used on either liquid or gas fuel (*Journal of the Institution of Petroleum Technologists and Record of Transactions*, vol. 1, part 4, p. 195, June 1915, 33 pp., 21 figs. *cd*).

STRICKLAND DOUBLE-ACTING FOUR-STROKE CYCLE ENGINE

Description of the Strickland engine, which, working on a four-stroke cycle, gives a power impulse every revolution in each cylinder. As shown in Fig. 2, there is a two-diameter piston with the usual combustion space at the top of the cylinder. Midway of the cylinder length is an annular space left when the piston is at the top dead center, and this forms a secondary combustion chamber. The action is as follows: As the piston descends under the impulse of a charge in the upper combustion chamber, the lower part of the piston is

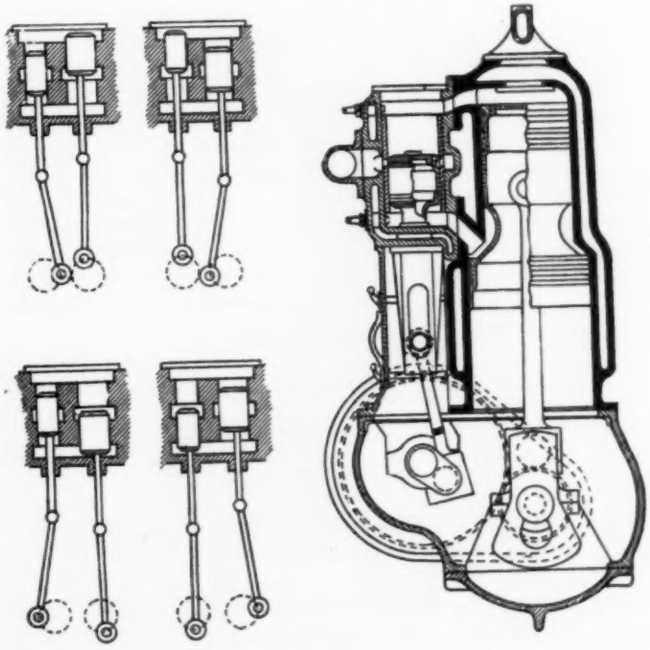

FIG. 2 STRICKLAND DOUBLE-ACTING FOUR-STROKE CYCLE ENGINE

drawing in gas from the carburetor. On the reversal, at the bottom of the stroke the upper piston commences its exhaust stroke and the lower part rises on the compression stroke. In the next stroke, firing and expansion take place in the lower part and intake on the upper piston. For the last stroke the upper part is compressing, while the lower is exhausting.

Had poppet valves been used, a mechanism to control the intake and exhaust would necessarily have proven to be somewhat complicated. Therefore, the inventor uses a single pair of double-acting piston valves to control both the upper and the lower cycles. These are shown on the left of the engine in the illustration. The valves are operated from a second crank shaft driven by the gear from the main crank shaft.

The inventor lays particular stress on two points in connection with his design. The first is that the effect of the piston valves is to extend the indicator diagram, thus making for increased thermal efficiency. This is said to be so because the piston valves are near the top of their stroke during suction and descend during the firing stroke, thus having the

effect of making the cylinder bigger during the expansion stroke than it is during the suction stroke. The other claim is that for a given power output the space occupied is much smaller than with a four-stroke cycle engine of equivalent power.

The article does not state whether such an engine has been actually constructed, and gives no data of any tests of an engine. Neither does it state in which sizes such an engine is supposed to be most efficient (Four-Cycle Engine—Two-Stroke Effect, *The Automobile*, vol. 34, no. 22, p. 974, June 1, 1916, 2 pp., 3 figs. *d*).

THE USE OF OIL ENGINES FOR PUMPING, C. R. Knowles

The use of oil engines instead of gasoline engines has been due to increased consumption of water necessitating larger pumps and heavier power, together with the increase in the cost of gasoline. This has been done in many cases by converting the existing gasoline equipment to kerosene and distillate engines by the additions of the proper attachments. A series of efficiency fuel tests with distillate, alcohol, kerosene, gasoline and motor spirits were made, pumping against a total head of 61 ft.

It was found that distillate is the most economical of the fuels used. The power obtained from the use of kerosene was practically the same as from distillate, the only difference being in the price of the two fuels.

Another series of tests with a 12 h.p. 4-cycle engine showed that the engine consumed the same amount of 39 deg. distillate per h.p.-hr. as gasoline. The article also reports data of tests with the semi-Diesel engine. (*Journal of the American Water Works Association*, vol. 3, no. 2, p. 356, 8 pp., *cg*).

Lubrication

LUBRICATION REQUIREMENTS FOR WIRE ROPE, George R. Rowland

Data on lubrication of wire ropes secured from one of the largest rope manufacturers in this country as well as by the company with which the writer is connected.

The latter has made measurements on a 3500-h.p. twin tandem reversing engine, which showed that there were 319 sq. ft. of actual frictional surfaces to be lubricated, which shows that every foot of wire rope is a moving part subject to friction, and to secure its proper efficiency and service it must be given the same attention in the way of lubrication as any other mechanical device.

Because of the demand on the part of purchasers that the manufacturers give a guarantee to the life and performance of the ropes, the question of efficiency in lubrication has assumed a considerable importance. A careful investigation of the ropes used in all classes of service has shown that no two manufacturers are using the same grade of rope lubricant and that the materials most commonly used contain tar, graphite and other fillers in large proportions. Such materials have the effect of only partially protecting the external parts of the rope and at low temperatures will crack and peel. This has the effect of permitting the deteriorating elements to attack the internal parts of the rope, and instances are known of ropes suddenly breaking while the visible wires show no sign of deterioration, it being invariably found upon examination that the internal wires have perished by corrosion.

Ordinary black oil or what is known as "waste oil" are worthless as rope lubricants. A still worse practice is that of giving the ropes an external coating or slushing by the manufacturer. An efficient wire rope lubricant must be free from any material that will attack the constituent parts of the rope, must remain soft and pliable under all atmospheric conditions, must not be subjected to evaporation, must be insoluble in water and must be unaffected by water heavily charged with chemicals such as exist in some operating conditions. Further, it must be of such a nature that it will enter between the wires in the strand and between strands to the core of the rope when the rope has been put into service, preserving the core as well as the metal which surrounds it. In addition, it should be equally efficient as a lubricant for sheave wheels, drums, pulleys and other bearings over which the rope passes.

Too little attention has been given to the initial lubrication of wire ropes, particularly as regards proper saturation of the hemp center. The method of application of lubricant in service is not always correct. The proper way to apply the lubricant is to use a split box of sufficient dimensions to permit of its holding about 25 lb. of the lubricant to be used, constructed with a hole in the center large enough to permit of the passage of the largest rope to be coated. The lubricant should be thoroughly liquefied in a metal condenser, and after it is poured into the split box the rope should be permitted to pass slowly through the box. (From *Lubrication*, through *The Blast Furnace and Steel Plant*, vol. 50, no. 6, p. 286, June, 1916, 2 pp. *p*).

Machine Parts

OVAL FLANGES FOR STEAM, AIR, WATER AND OTHER PIPES, Fairfax

In the British Standard flanges for pipes and fittings for use under steam and water pressure are all circular. There are, however, still a great many uses for oval flanges under certain conditions. For example, for lower pressures, say air pressure below 100 lb. per sq. in., and for exhaust piping or piping where pressures are used below that of the atmosphere, oval flanges will be used, just as they will for very light pressures where brass fittings of copper pipes are essential. The article gives a list of oval brass or brazing metal flanges suitable for copper pipes, valve, cock, etc., working under a vacuum or for use up to a gage pressure of 15 lb. per square inch (Table 2A) and a list of oval flanges suitable for use on wrought iron pipes, brass or cast iron valves, cocks, and pipes working under gage pressures above 15 and up to 100 lb. per sq. in. (Table B).

Under certain peculiar conditions oval flanges are also used for much higher pressures such as in connection with hydraulic pressure pipes and fittings, from 700 to 900 lb. per sq. in., and even as high as 1200 lb. per sq. in. The writer gives two tables for these ranges of pressure. The article is not finished (*Mechanical World*, vol. 59, no. 1534, p. 253, May 26, 1916, 2 pp., *gp*).

Machine Shop

NEW HIGH-SPEED STEELS

The difficulties connected with the supply of tungsten and other rare metals used in the manufacture of high-speed steel led to intensified metallurgical research, and it is stated that Darwin and Milner of Sheffield, England, have discovered an alloy substitute for high-speed steel which contains neither tungsten, molybdenum, cobalt nor vanadium, and which, it is

said, can be cast in iron or sand molds suitable for grinding to tool shapes with an emery grinder without forging, hardening or heat treatment of any kind. It is further claimed that the material possesses the thermal stability which enables it to cut to a red heat. Actual cutting tests were made with a tool prepared from 1.25 in. square bar on a round bar of high tensile steel containing 0.32 carbon, 0.07 silicon, 0.59 manganese, 0.024 sulphur, 0.012 phosphorus, 1.26 chromium and 3.28 nickel. Quarter-inch cuts were taken at speeds of about 50 ft. and cuts of 1/64 in. at speeds 150 ft. with, it is said, very satisfactory results. Particulars of the composition of the alloy are at present withheld though patent rights were secured in October, last year (*Mechanical Engineer*, vol. 37, no. 957, p. 394, May 26, 1916, 1 p. *d*).

JIG AND FIXTURE DETAILS, R. F. Pohle

The article presents data on details of jigs and fixtures, together with tables embodying the practice of the General Electric Company works at Lynn, Mass. It covers the subjects of jig stop pins, spring pins, hinge pins, clamps and straps, latches and swing bolts (*Machinery*, vol. 22, no. 10, p. 839, June 1916, 3 pp., *dp*).

Measuring Instruments

SIMPLIFIED CONDENSATION HYGROMETER, Charles Margot

Description of a condensation hygrometer which is a modification of the one described by Crova in 1883 for use especially in measuring the moisture in air in places of difficult access.

As shown in Fig. 3, it consists essentially of an exterior cylindrical casing or cooling chamber, *E*, 8 cm. in diameter and 2 cm. deep. On the side towards the observer, this chamber is closed by a thin disc of nickeled brass, perfectly flat and polished. The other face has a small opening, closed by a glass, which permits the level of the ether to be seen. The second chamber, truncated in shape, is screwed on the first chamber and is closed by a glass, which permits the seeing of the condensation of the vapor on the nickel plated surface. It has three auxiliary apparatus: (1) Part *C*, which, by means of suitable tubing, is placed into communication with the air, the hygrometric state of which has to be measured; (2) *D* is connected by a rubber tube with the tube *B*, the end of which is immersed into ether; (3) *T* is used to hold the thermometer. Air is taken in through *A* by means of a water jet or some other kind of suction device. It passes first the cooling chamber where the condensation is effected, and then bubbles through the ether. The observer follows the course of condensation and can see the slightest trace of dew appear and disappear on the central part of the polished disc. As the deposits of dew appear first in the center of the disc, while the parts nearer the rims remain clear, it is easy to make observations. It is advisable to place the apparatus on a solid cast-iron foundation with an intervening wooden support, and not on a metal support, so as to avoid the conduction of heat to the apparatus. As the first chamber is quite large, there is no danger of the air circulating at a velocity too great to allow time to take the temperature of the cooling disc. A series of tests have shown that the same precision is obtained whether the two chambers are located in series or separately (*Modèle simplifié d'hygromètre à condensation*, Charles Margot, *Archives des Sciences Physiques et Naturelles*, vol. 41 (Quatrieme periode), no. 3, p. 222, March 15, 1916, 4 pp., 1 fig. *de*).

STUDIES OF INSTRUMENTS FOR MEASURING RADIANT ENERGY IN ABSOLUTE VALUE, W. W. Coblenz and W. B. Emerson

One of the real needs in the measurement of radiant energy is a reliable radiometer which evaluates the observations in absolute measure. Such an instrument should be a primary one, capable of measuring radiant energy directly. Actually, however, there is no such primary instrument, although there are several apparently trustworthy methods for making measurements of radiation in absolute value. The U. S. Bureau of Standards has, therefore, undertaken to prepare standards of radiation and to study various instruments used in making absolute measurements of radiation. The present paper reports on the results obtained with one of these instruments,

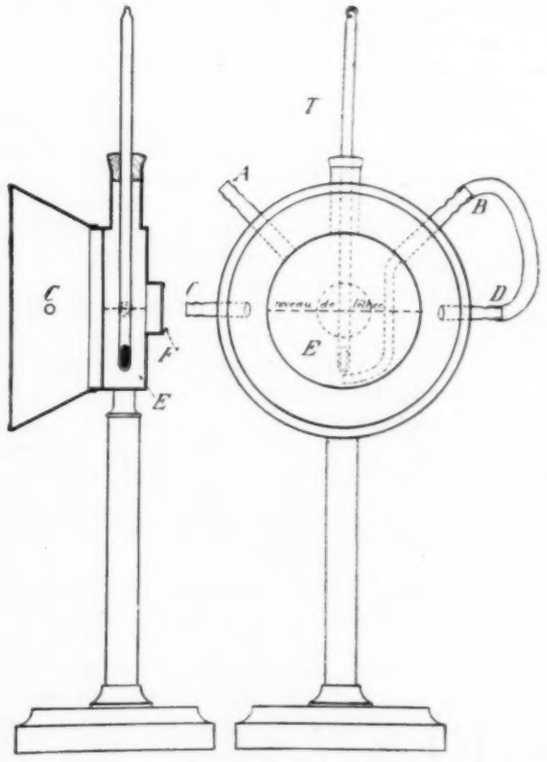

FIG. 3 MODIFIED CROVA CONDENSATION HYGROMETER
Niveau de l'éther—level of ether

and also presents the evaluation of the coefficient or the so-called Stefan-Bolzmann constant of total radiation of a uniformly heated cavity (black body).

In a previous communication from the Bureau the results of a study of the so-called Radiobalance were given, which showed that while this instrument has many good points it did not appear to be sufficiently reliable for a primary instrument.

The present paper describes in detail the apparatus used in the present series of tests, and the method of making observations and reduction of data.

While it is difficult to estimate the accuracy attained in the final results, it is important to note that the value of the radiation constant is based upon observation with a far greater number of receivers than were hitherto employed, the receivers being differently prepared and operated under various conditions as to width and thickness of the metal strip, distance between potential terminals, kind and thickness of the

absorbing layer, etc. The data are presented in the form of tables.

On the whole, it was found that the device described in the paper may be used as an instrument of precision because of its quickness of action, freedom of surrounding conditions, high sensitivity and simplicity of operation. It can be much simplified and then used as a radiation pyrometer. In practice it is advisable to calibrate the receiver by exposing it to a black body heated to about 1000 deg. cent. when it is desired to make the refined radiation measurements. A complete radiometric outfit, including the radiator, has been placed in an evacuated inclosure for the purpose of making in the future radiation measurements in absolute value at certain fixed temperature points as defined by the melting points of metals such as gold, silver, palladium and platinum. In this manner it is hoped to eliminate the effect of atmospheric absorption, and to otherwise improve the reliability of the measurements.

The loss of energy by diffused reflection from the blackened surface of the receiver was investigated and it was found that there was but little difference in the reflecting power of the different surfaces examined. (*U. S. Bureau of Standards, Scientific Papers*, No. 261, p. 504, March 4, 1916, 47 pp., 6 figs. *e.*)

Mechanics

SPUR GEARING, Daniel Adamson

Paper read before the Institution of Mechanical Engineers on May 19 last. It discusses the design of spur gearing, the materials used and the mechanical properties of the finished gears. Among other things it presents interesting historical data on the development of various views on the mechanics of spur gears and a chronological list of references.

Because of the fact that Lasche's investigation, originally printed in the *Zeitschrift* of the German Society of Engineers, has never been translated into English and is not easily accessible, the author gives an extended abstract of it. Lasche investigated the variation in the amount of sliding at different parts of the tooth faces and flanks and from this developed his "wear characteristic." This wear characteristic is dependent upon the contact pressure and the amount of sliding between contiguous teeth. Lasche has also shown the importance, as affecting the working of gear teeth, of the relation between theoretical arc of contact and circumferential pitch, called for convenience "duration of contact" and usually expressed in terms of circumferential pitch. When the theoretical arc of contact exceeds unity, the duty will be distributed between the different teeth in contact at a time when the rate of wear would otherwise be at its highest value.

The factors to be considered when estimating suitable proportions to resist wear are: P = pressure to be transmitted at pitch line, N = number of revolutions per minute, e = estimated number of teeth in contact, and b = breadth of teeth. A table of actual examples from practice and experiment is given in Lasche's paper to enable a suitable value to be placed upon PN/eb according to the conditions of the working.

As to variations in stresses due to irregularities in pitch, Lasche gives calculations of a typical example from practice, showing that while at moderate speeds this is not serious, yet as the excess load due to irregularities will increase as the square of the velocity at higher peripheral speeds, trouble is experienced that cannot be accounted for by calculations based upon the transmitted load alone.

Lasche strongly advises the separation of revolving masses, as, for example, armatures of motors, from adjoining masses such as the large gear wheels of the second motion, by some elastic medium such as a length of shaft or a flexible coupling, so as to allow slight variations in angular velocity due to unavoidable errors in gear cutting to take place without giving rise to destructive loads between the teeth.

The writer attaches great importance to the selection of the best material for gears. He calls attention to the fact that while heat treatment may be quite feasible with large masses such as armor plates and gun tubes, where the value of each piece makes it possible to maintain an expensive laboratory and staff to check the processes and the results, this is not so convenient in ordinary machine shops. He foresees stricter requirements as to the constituents of steel used for gearing.

TABLE 2A VACUUM TO 15 LB. PER SQ. IN. GAGE PRESSURE

Nominal Size: Bore of Pipe	A	B	C	D	E	F	G	H	J	K
In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
1/2	3	1 3/4	2 1/8	3/8	5/16	1/2	1	7/16	5/16	5/32
3/4	3 3/4	2	2 5/8	1/2	3/8	5/8	1 1/4	9/16	3/8	5/32
1	4	2 1/4	2 7/8	1/2	7/16	3/4	1 1/2	9/16	7/16	5/32
1 1/4	4 3/4	2 5/8	3 7/16	5/8	1/2	13/16	1 7/8	11/16	1/2	3/16
1 1/2	5 1/4	3 1/8	3 7/8	5/8	1/2	7/8	2 1/4	11/16	1/2	3/16
1 3/4	5 1/2	3 1/2	4 1/8	5/8	9/16	15/16	2 1/2	11/16	9/16	3/16
2	6	3 7/8	4 1/2	5/8	9/16	1	2 7/8	11/16	9/16	7/32

TABLE B ABOVE 15 TO 100 LB. PER SQ. IN. GAGE PRESSURE

Nominal Size: B. S. Pipe Thread.	A	B	C	D	E	F	G	H	Cast Iron		Brass	
									J	K	J	K
In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
1/2	3 3/4	2	2 5/8	1/2	1/2	7/8	1 3/8	9/16	1/2	5/16	3/8	5/32
3/4	4	2 1/4	2 7/8	1/2	5/8	1	1 5/8	9/16	5/8	5/16	7/16	5/32
1	4 3/4	2 5/8	3 7/16	5/8	3/4	1 1/8	1 7/8	11/16	3/4	5/16	1/2	5/32
1 1/4	5 1/4	3 1/8	3 7/8	5/8	7/8	1 1/4	2 1/4	11/16	7/8	3/8	1/2	3/16
1 1/2	5 1/2	3 1/2	4 1/8	5/8	1	1 3/8	2 1/2	11/16	1	3/8	9/16	3/16
1 3/4	6	3 7/8	4 1/2	5/8	1 1/8	1 1/2	2 7/8	11/16	1 1/8	3/8	9/16	3/16
2	6 3/4	4 3/8	5	3/4	1 1/8	1 5/8	3 1/8	7/8	1 1/8	7/16	5/8	7/32
2 1/2	7 1/2	5 1/4	5 3/4	3/4	1 1/4	1 3/4	3 7/8	7/8	1 1/4	7/16	3/4	1/4

As to the allowable working stresses, the author cites the work of E. R. Walker (1868), F. Reuleaux and Wilfred Lewis (1892), as well as the paper of Marx in the *Transactions of The American Society of Mechanical Engineers*, vol. 34.

In the matter of maximum speeds, the author holds that a velocity of 2500 ft. per min. is quite feasible, as shown by actual examples which he cites. In fact, an example has come to his notice in private correspondence of a pair of machine cut bevel wheels, ratio 3 to 1, transmitting 1500 h.p., pitch line velocity 3000 ft. per min., load 1570 lb. per in. of width. In the matter of durability, the author cites an investigation by Dr. Otto Schaefer, who gives a table showing the variation in loading according to the total number of revolutions

estimated to be made by a wheel before wear has so weakened the teeth as to bring the stress due to bending up to a predetermined maximum.

Dr. Schaefer gives the formula: $W = P \times F \times K$, where W = safe working load in lb., P = circular pitch in in., F = width of face in in., and K is a variable dependent upon the material used and the circumstances of the drive. The author gives a table for K converted into British units from the data in Dr. Schaefer's article (*Institution of Mechanical Engineers,* Advance Paper E, 37 pp., 17 figs., *htA*).

Errors of Screws

The present article forms part of a pamphlet entitled "Notes on Screw Gauges" and published for the National Physical Laboratory, of Teddington, England.

A screw is defined by the profile of the thread as exhibited by a section cut through the axis of the screw. The Whitworth thread has seven elements, error in any one of which may be sufficient to cause a gage to reject work which ought to pass. These elements are: Full or major diameter; core or minor diameter; effective or pitch diameter; pitch; angle; form at crest; form at root. The most important, and likewise most difficult to control, are the pitch and the effective

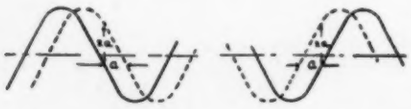

Fig. 4 Ring and Plug Screw of Similar Thread Form But Slightly Different Pitch

diameter. With the exception of the radii at the crest and root of the thread, which may be ill-formed without affecting the accuracy of other dimensions, an error in any one of the elements of a screw thread is necessarily associated with some corresponding error in one or more of the remaining elements. The most important case of this is found in the close association of pitch and effective diameter errors.

Suppose the full and dotted outlines in Fig. 4 to represent a ring and a plug screw of similar thread form, but of slightly different pitch. Let the maximum relative displacement of any thread in the length engaged be $2a$. Then the extreme threads will be displaced axially by $+a$ and $-a$ respectively. The diagram shows that in this case the parts will not go together unless the axial displacement is accompanied by a radial displacement which, allowing for the angle of the thread, is about equal to $2a$. This is doubled on the diameter so that as a rough rule it may be taken that any error in pitch has to be compensated by an error of twice the amount in effective diameter.

The errors in all the different elements should be such that their combined effects do not produce a shape lying outside the specified maximum limits in the section of the screw which is to be gaged. Hence, considering a gage correct in all respects except effective diameter and pitch, we see that if the limit of tolerance on effective diameter be 0.0006 in., that on pitch between any two points on the length of thread engaged must not exceed 0.0003 in. either short or long.

There are two kinds of error in pitch. First, there may be a progressive error increasing with the length of the screw, or there may be a variable error of either regular or irregular kind, or both may occur together. If the variable error is repeated at regular intervals, it is called periodic error and is usually due to play or to faulty adjustment of the lead screw of the lathe. If the lathe has a lead screw of ¼-in. pitch, there will be alternating lengthening and shortening in the pitch of a screw cut by it every ¼ in. run of the screw whatever be the actual pitch cut. When the pitch error is of variable character, a somewhat wider error than the limit of tolerance may be allowed, provided this is compensated by a corresponding error in effective diameter, and in such a way that the combined effect is to give an equivalent effective diameter lying within the limits of tolerance allowed (*Notes on Screw Gauges,* pamphlet, published by W. F. Parott, The Causeway, Teddington, Middlesex, England, abstracted from reprint in *Mechanical World,* vol. 59, no. 1531, p. 206, May 5, 1916, 2 pp., 6 figs., article not finished. *p*).

Rectangular Pressure Vessels, H. J. Vander Eb

The paper is an abstract from an article in *The Locomotive* for April, 1915, and discusses methods of calculation of proper plate thickness of rectangular or square vessels, and of the pressure that can safely be allowed in such a square vessel of a given thickness of material.

The author derives certain formulæ, the notation of which will be seen from Fig. 5. If S represents the direct stress in the inner skin of the material and P the internal pressure, then

$$S = P \frac{R_1^2 + R^2}{R_1^2 - R^2} \qquad [1]$$

As regards the tendency of the square vessel to become cylindrical, we may consider the curved corners as short curved beams; in a length of vessel of 1 in. there will be two groups of four beams, namely four straight ones and four curved ones, the straight beams being the sides of the structure. Because of the fact that the four side and corner beams form one continuous structure but bend in opposite directions from one another, it follows that for elastic deflections the shortening of the inner fibres of one set of beams is equalized by a corresponding elongation in the inner fibres of the other set of beams; this may be expressed by saying that with regard to the total inner surface of a square vessel, the sum of all elongation equals the sum of all contraction in that surface, so long as the elastic limit of the material of the vessel is not exceeded by the attendant fibre stresses. The following formulæ give the total unit fibre stress in the metal of the inner skin of the curved beam (S_1) and the maximum unit stress in the straight beam (S_2) respectively.

$$S_1 = P \left(\frac{R_1^2 + R^2}{R_1^2 - R^2} + \frac{l^2}{5.02\, t^2 r} \right) \qquad [2]$$

$$S_2 = P \left(\frac{3l^2}{4t^2} + \frac{D}{2t} \right) \qquad [3]$$

where P is internal pressure and the remainder of the notation is as in Fig. 5.

The article also gives information as to the distances of the neutral surface to the concave side of the curved beams, of importance because the fibre stresses in the metal of the concave side of the beams vary inversely as these distances.

The allowable pressure on the vessel should always be based on the weakest part, i. e., whichever of the beams is found stressed the highest. These formulae take also into account the all important radius of the corner fillet. (*Machinery,* vol. 22, no. 10, p. 861, June 1916, 2 pp., 3 figs. *t*).

Presses

PRESSURE DEVELOPED BY FRICTION SCREW PRESSES, F. J. W. Sparkuhl

The article describes the operation of the type of presses more commonly known in this country as percussion or spindle presses, and gives formulæ for the calculations of pressure developed by them.

It gives formulæ for calculating the coefficient of efficiency of the screw during the actual embossing action, the total energy stored up in the fly-wheel of the press, the amount of work required for raising the reciprocating parts, the pressure developed, and finally the velocity of the screw. The paper, among other things, is illustrated by a diagram showing the amount of energy stored up in the fly-wheel at different points in cycle, and gives a fully worked-out example showing the application of the formulæ presented in the article (*Machinery*, vol. 22, no. 10, p. 846, June 1916, 4 pp., 4 figs. *dm*).

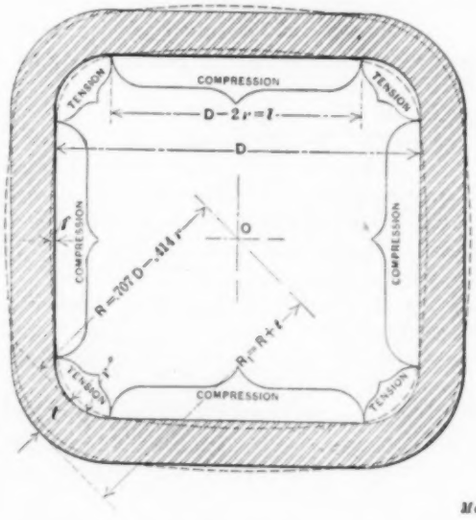

FIG. 5 NOTATION USED IN FORMULAE OF STRESSES IN RECTANGULAR PRESSURE VESSELS

Railway Engineering

GOFF'S ELECTRO-PNEUMATIC BRAKE SYSTEM

Description of the Goff electro-pneumatic brake system as applied to street cars or steam railroad service.

Although no triple valves are required, the brake is automatic. The brake may be applied or released in full or graduated on or off with any desired pressure. Accidental bursting of the air hose or brake pipe does not interfere with the application or the release of brakes.

In the device, an ordinary electro-magnet is used to control the flow of compressed air from the auxiliary reservoir to the brake cylinder and another to control the flow from the brake cylinder to the atmosphere when a release is desired. The system differs from the usual electrically controlled brake in that the application magnets are energized when the brake is applied, and when these magnets are de-energized by a movement of the brake valve on the locomotive or by rupture in the brake pipe, the magnet valves will admit compressed air to the brake cylinder applying the brake. The magnet valve controlling the flow of air from the brake cylinder is normally closed with the magnet de-energized, and when a release of brakes is desired the release circuit is closed at the control switch, energizing the release magnet and drawing the exhaust valve away from its seat, opening the brake cylinder to the atmosphere. It is stated that this brake system will be set up and be in operation at the Master Mechanics' Convention at Atlantic City this year. (*Railway and Locomotive Engineering*, vol. 29, no. 6, p. 199, June 1916, 2 pp., 2 figs. *d*.)

FRENCH HOSPITAL TRAINS

The paper describes the French system of trains for transporting the wounded from the battle line to the hospitals in the rear, where proper care can be taken of them. Among other things is described a new method of carrying the wounded in the trains.

Some of the disadvantages of using third-class passenger coaches of the corridor type for the transportation of the wounded lay in the facts that they are rather heavy, and in addition had to be cleared of their old transverse seats and provided instead with iron cots. Besides this, the use of beds for the transportation of the badly wounded is objectionable in itself, because the men have to be moved from the stretchers to be placed in the coach, and again from the coach to be transferred to the hospital, which means loss of time and suffering for the men.

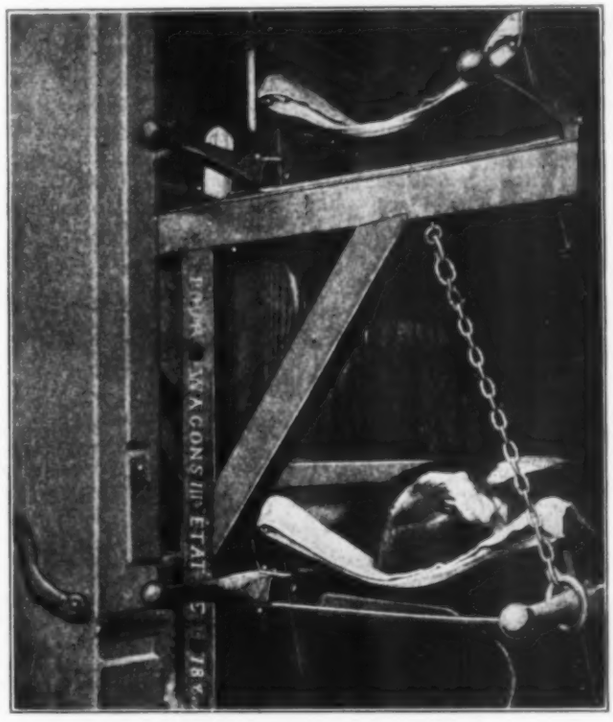

FIG. 6 BELTZER FRAME SUPPORT FOR STRETCHERS

Dr. H. L. Beltzer last spring devised a frame support for stretchers (Fig. 6) which is both simple and practical and makes it possible to utilize any English or continental passenger car without a single change in the seating arrangement, without injuring the car and without installing in it a single bed. When the stretcher is placed in the frame its handles are fitted into a set of iron rings, each held by a spring which takes up any kind of shock. When the train arrives at its destination there is no shifting of the wounded man when he is loaded into an ambulance, as the stretcher goes with him right to the hospital. In other words, the device means that

a man can be carried from the battle field to a hospital hundreds of miles away without a change of bed. (How French Hospital Trains Help to Save the Wounded, *The Railway Gazette*, vol. 24, no. 18, p. 501, May 5, 1916, 4 pp., 6 figs. *d*).

THE STRENGTH AND WEAR OF LOCOMOTIVE TIRES, E. L. Ahrons

A brief historical discussion of the strength of locomotive tires covering mainly European practice.

As to the actual wear of locomtive tires, the author refers to the papers by A. J. Hill in the *Proceedings of the Institution of Civil Engineers*, 1895, and G. Hughes in the *Proceedings of the Institution of Mechanical Engineers*, 1909. The writer has attempted to obtain a proportionate figure for the wear of tires which takes into account mileage obtained from a wear of 1/32 in., tensile strength, diameter, and weight on the wheels. A number of tires from different classes of passenger engines (with brakes on the wheels) which have been taken off when worn out were selected. Specimens had been taken from the worn tires and the tensile strength, both with and across the grain, were ascertained. The total mileage and the wear being known, the number of miles run per 1/32 in. of total wear including re-turning is given. To this mileage 4 per cent is added for single engines, 3 per cent for four-wheel coupled engines and 2 per cent for six-wheel coupled engines to allow for ordinary and imperceptible slipping. A weight of 15 tons on the pair of wheels was taken as standard. The results obtained are given in several tables. In certain cases, namely, the 6 ft. coupled engine, the tensile strength of the tires is extremely low, but in spite of this these tires run a large mileage. The chemical analysis of these two tires showed only a trace of carbon, although they were of Bessemer steel; in fact, one of the tires was iron with an added mixture of manganese (0.259 per cent carbon trace) (*The Engineer*, vol. 121, no. 3151, p. 411, May 19, 1916, 2 pp., *et*).

Refrigeration

A THEORY OF COOLING TOWERS COMPARED WITH RESULTS IN PRACTICE, B. H. Coffey and George A. Horne

This paper is a continuation of the one published in the *A.S.R.E. Journal*, November, 1914, and January, 1915.

As a result of the previous year's experience, the writers arrived at the conclusion that certain apparent inconsistencies in the results would be smoothed out by taking, if possible, all readings at the site. Arrangements had been made to have installed a standard anemometer upon the tower so as to obtain a continuous record of wind velocity. Likewise, arrangements were made to have at the site a recording wet and dry bulb thermometer to check the records from the Arsenal Station, Central Park, New York, so as to eliminate discrepancies believed to be of considerable magnitude, due to difference in wet bulb temperatures at the two localities.

No complete theory underlying the operation of cooling towers is presented in the papers, the writers stating that their data are not yet complete enough for such an undertaking. They arrive, however, at the following conclusions: Considering the difference between the final water temperature and the wet bulb temperature or approach to the wet bulb as a measure of tower efficiency, the degree of approach is affected by four variables, (1) the cooling range or number of degrees of heat extracted in the tower; (2) the position of the wet bulb in the thermometric scale—a wet bulb temperature that is high on the thermometric scale can be more closely approached than one at a lower temperature level; (3) the ratio by weight of air to water in contact throughout the cooling process; (4) the ratio of exposed water surface to the weight of water cooled in unit time. Any consistent theory must, therefore, be capable of expressing the effect of these variables upon the terminal temperature, which, as well as the wet bulb temperature, is the wet bulb approach. The writers give several plates containing characteristic curves derived from this theory, which show the effect of these variables on the cooling water, but, as they state, they have not yet succeeded in developing general formulæ for determining these curves for the variables. In order to compare the theories with practice, curves of the theoretical results were prepared, referring to wet bulb approach as a standard in which the effect of the selected variable is shown through a wide range. Such curves are drawn, for example, with the wet bulb or wind velocity as variables.

Curves from experimental data were drawn, and they still show obvious inconsistencies and discrepancies, due, probably, to the impossibility of expressing with the recording instruments the exact conditions that exist.

A large section of the paper is devoted to the determination of the constant θ, which is the total heat loss per hour per square foot of surface per mercury-inch difference of pressure between the values of the function ω at the cooling surface and at the wet bulb, this difference in the value of ω being the measure of the total heat loss from the cooling surface to the atmosphere.

To evaluate the constant θ it is necessary to determine the weight of water evaporated in known time from a known superficial area under a known difference of pressure expressed in mercury inches. The writers state the conditions which have to be satisfactory in order to obtain correct values, and give a table representing the summary of evaporation tests made to determine this constant. The mean value of θ from the eleven experiments made is 652.5 B.t.u., and the maximum departure of any single experiment from this mean is 4 per cent, which the writers think justifies the belief that a fairly close approximation of the true value has been obtained. The evaluation of the constant θ makes it possible to apply the theory in its present form to any tower employing film cooling surface exclusively, as with this form of surface the wetting in contact with the atmosphere can be accurately calculated. (*A.S.R.E. Journal*, vol. 2, no. 6, page 5, May, 1916, 27 pp., 7 figs. *etA*).

AMMONIA CONDENSER DATA, Henry Torrance

A brief and interesting paper reporting tests on a double pipe ammonia condenser of the injector type (continuation of previous tests which showed that in a double pipe condenser it does not matter whether the ammonia runs up-hill or down-hill, water to run counter-current, and that "flooding" makes no gain).

In the present series of tests there was inserted a gate valve on the fourth run of pipe from the bottom, so that when closed the gas first passed through three runs of pipe at the bottom and was first cooled by waste water; after which it entered the top of the coil and ran down-hill as usual. Thus arranged, the coil became like a condenser of the ordinary type. In Fig. 1 are plotted the weights of ammonia condensed as indicated.

As regards the theory of condensation, the author states: In a condenser where vapor is condensed, the vapor should

touch the pipe surface; in a brine cooler where liquid is evaporated, the liquid should touch the pipe surface; a condenser should run empty as far as possible; a brine cooler should run flooded as far as possible.

The author presents the data of his tests in the form of a table where *the results shown appear a little better with the valve closed* considering that the surface was reduced.

In the discussion which followed, V. R. H. Greene, who cooperated with the writer of the paper, spoke of the use of baffle plates on the side of the cast-iron shell to receive the liquid as fast as condensed and take it away. These tests have been described in a previous paper before the same society. He gave further data as to the method by which the relative velocity of the vapor in the pipes had been ascertained.

F. L. Fairbanks spoke of his own tests to establish the comparative efficiency of the flooded type condenser on one hand, and the older, or dry, type on the other. A condenser which he had designed and had been experimenting with was

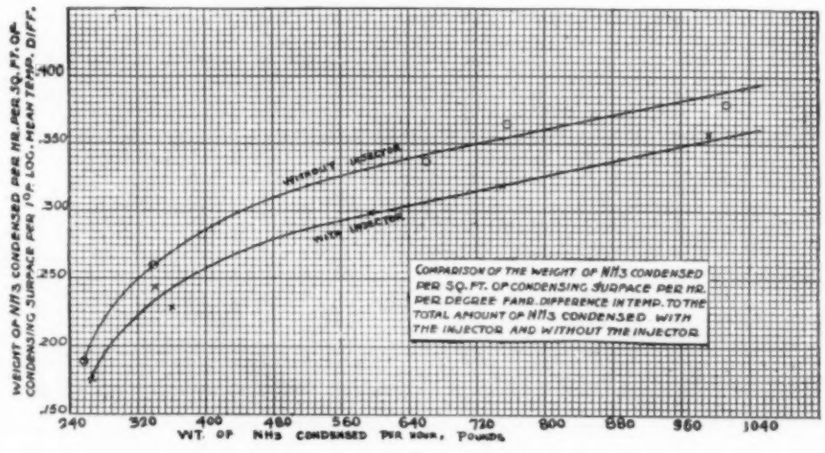

FIG. 7 AMMONIA CONDENSER DATA

of the jet type in which the principles of the jet steam condenser were utilized. The jet condenser for ammonia was designed for a capacity of 1000 tons in 24 hours, and was only 24 in. in diameter and 6 ft. high over all. The cool anhydrous ammonia from the liquid coolers was pumped to the liquid jet in the condenser by a large pump driven by steam, making it possible to spray through a special nozzle into the gas coming from the compressors, 1 to 600 gal. per minute of the liquid. The gas and liquid were then brought more intimately into contact with each other by a series of baffles, and the resultant condensate flowed by gravity through liquid coolers which brought it down to within 3 to 5 deg. of the temperature of the condensing water. From the liquid cooler it flowed by gravity to the ammonia pump and thence to the jet of the condenser again.

The gas flowing to the condenser under testing conditions averaged about 175 deg. and the thermometers indicated that with a small amount of liquid spray the superheat disappeared instantly or, at least, in the 18 in. distance between the thermometers. When the amount of liquid was increased to the maximum, the only result in every case was to raise the condenser pressure from 5 to 10 lb. in addition to the pressure shown when condensing by the normal method without the liquid jet.

The speaker believed that the *introduction of the liquid into a condensing gas under certain conditions retards rather than facilitates condensation*, and consequently raises the condenser pressure. In his opinion such conditions are present in the flooded type of condenser, which may account for the contention by Mr. Torrance that it is more efficient without the liquid jet than with it.

As stated in the concluding remarks of the author, it has been claimed that the flooded condenser is the greatest improvement made in the refrigerating industry in recent years. These tests, however, raise the question whether this is true. (*A.S.R.E. Journal*, vol. 2, no. 6, p. 33, May, 1916, 17 pp., 3 figs. *ecA*).

Safety Engineering

GASOLINE, CHAMOIS AND SPARKS, Arthur D. Ewell

In the press, occasional allusions have appeared to the danger of filtering gasoline through chamois in cold weather. It was stated that the " friction " of the gasoline passing through the chamois produces opposite charges of static electricity in gasoline and chamois which occasionally results in sparks igniting the gasoline vapor and producing disastrous explosions.

Tests were made in the physical laboratory of the Worcester Polytechnic Institute with insulated chamois in the form of a funnel properly connected to a Braun electrometer. Different samples of gasoline were used at different heights of fall and under different weather conditions. Under proper normal conditions the potentials observed were always less than 20 volts, although on very cold days with high falls resulting in considerable splashing, potential differences of several hundred volts were sometimes found.

The author concludes that the passage of gasoline through chamois does not give rise to potential differences sufficient to produce sparks, and that the sparks and ignition reported may have been due to discharge from fur coats or clothing to the metal of funnel or car (*The Journal of the Worcester Polytechnic Institute*, vol. 19, no. 4, p. 315, May, 1916, 3 pp., 1 fig. *e*).

GASOLINE FIRES CAUSED BY SPARKS WHEN FILLING TANKS, Herbert Chase

The author, chief engineer for the Automobile Club of America, discusses the possibility of fires created by frictional electricity generated by the passage of gasoline through a chamois or through other non-conducting material. He states that the U. S. Bureau of Standards at Washington has been conducting an investigation along this line, but has made as yet only a preliminary report, which establishes, however, that electricity is generated by the passage of gasoline, and under certain circumstances may be sufficient to cause a spark, which, again accompanied by certain conditions, may result in igniting gasoline vapor. The fact that accidents have not occurred more frequently is, in the opinion of the writer, presumably because, first, the heat of the spark is not always sufficient to ignite an explosive mixture, even though this mixture exists in the region where the spark occurs, and second, the proportion of air to gasoline vapor is most frequently not such that ignition can occur.

To eliminate entirely the possibility of fire when filling a gasoline tank, it is simply necessary to "ground," that is, to connect with the earth, the funnel or nozzle on the surface of which the charge is apt to accumulate. As a rule, most of the danger can be entirely averted by simply keeping the funnel or filling nozzle in metal contact with the tank being filled. The writer cites several cases of fire caused by sparks. (*Motor Travel*, vol. 8, no. 1, p. 37, June 1916, 2 pp., p.)

STEEL BELTS FROM THE POINT OF VIEW OF SAFETY OF OPERATION, Willemann

The article discusses the comparative dangers of leather and steel belts.

That steel belts may be used to advantage under certain conditions there is scarcely any doubt; but whether they are more or less dangerous than leather belts, especially in transmissions between two floors, is still a mooted question. Assuming now that two belts, one a leather one and the other a steel one, run as shown in Fig. 8A. Let both break on the lower side. What will happen? The leather belt, because of its weight and flexibility, will let its free end fall down. Then, as the pulley is still running, the belt will continue to move and its ends will describe an extended arc. This throwing apart of the ends of the belt can become a source of very considerable danger for the man on the lower floor, especially if the belt fastening is at one of the ends of the broken belt, which is very likely to happen, because that is where belts usually break. In Fig. B the leather belt is shown broken in its tension or upper side. In this case the entire belt is thrown violently away from its pulleys and may easily become entangled in the running machinery.

As to the steel belt, it may be assumed that its weight is only about one-eighth that of a leather belt designed for an equivalent transmission of power; hence the centrifugal force of a steel belt is correspondingly smaller. The instant the belt breaks the tension necessary for the transmission of power is lost, the belt has a tendency to occupy a position in a plane, becomes free of the rotating pulley and falls flat. It is, therefore, unlikely that a steel belt can do any harm if broken. The likelihood of a steel belt inflicting bad cuts is overestimated and can be reduced by rounding its edges. The contact with the running steel belt may become dangerous if the belt runs at a very high speed, but contact with a leather belt is likewise dangerous, and both should be protected by proper guards.

Perforated steel belts have the additional advantage that one can see at a glance that the belt is running.

Because of its lack of stretching, it is practically impossible to put on a steel belt while the shaft is running, which automatically eliminates one of the sources of accidents in belt operation, and also limits the field of application of steel belts to operations where it is not necessary to shift the belt very often. For this reason steel belts are not adapted for use on step pulleys. Besides, as the steps on the pulleys are seldom in precise correspondence with each other, the steel belt, because of its lack of ability to stretch, is inadaptable for this kind of work. In engine lathe work, where men are accustomed to shifting the belts from one pulley to another by hand, a steel belt would not do at all. The author concludes that the steel belt is no more dangerous than the leather belt, and he calls attention to a statement made in 1911 in a German periodical showing the very small number of accidents due to steel belt operation (*Stahlbänder und ihre angebliche Gefährlichkeit*, Willemann, *Dinglers polytechnisches Journal*, vol. 331, no. 6, p. 94, March 18, 1916, 1 p., 2 figs. *p*).

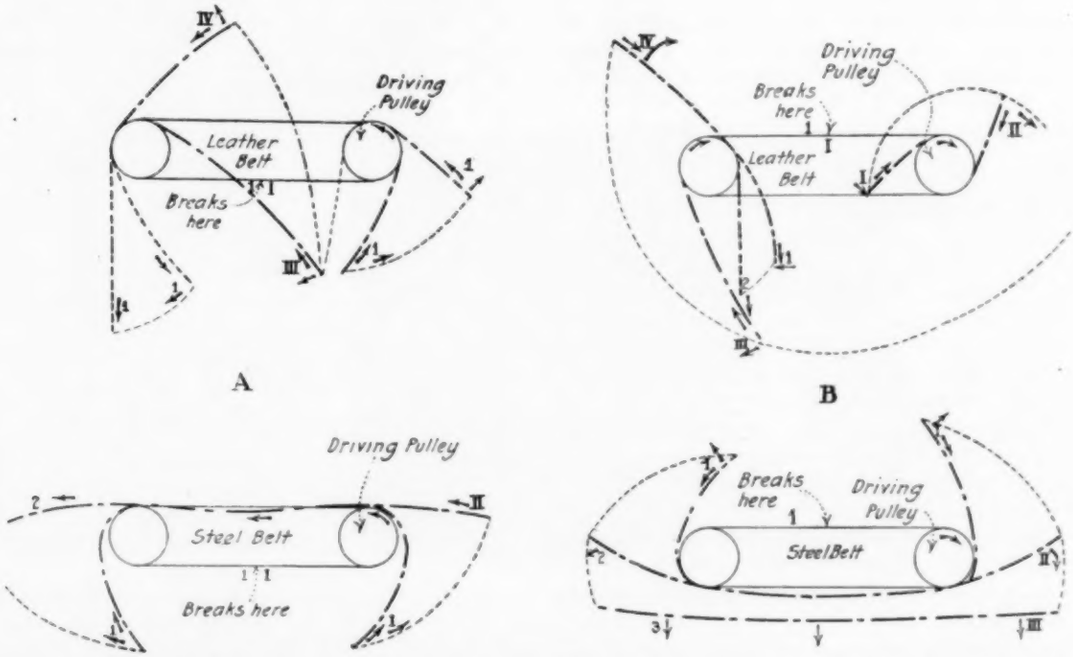

FIG. 8 DIAGRAMS SHOWING THE DIFFERENCE IN THE WAY OF RUPTURE OF STEEL AND LEATHER BELTING

Steam Engineering

RESULTS OF THE HALL OF RECORDS TEST

The article presents a summary of the report of the Bureau of Municipal Research, giving a comparison of the estimates

of the interested parties as to the results which would occur should the Hall of Records (which forms part of the municipal buildings in New York City) make its own current instead of purchasing it from the New York Edison Company.

The report of the Bureau of Municipal Research was compiled under the direction of Professors Carpenter and Lucke, and disagrees with both the city engineers and the engineers of the Edison Company. Because of the nature of the matter, only the two tables giving the three estimates by all the parties interested are here reproduced, the reader being referred for details to the original report. (*The Isolated Plant*, vol. 8, no. 4, p. 4, April, 1916, 3 pp., *ec*).

TABLE 3 RESULTS OF THE HALL OF RECORDS TEST

ESTIMATED REDUCTION IN PLANT OPERATING COST

	Estimated by the City	Estimated by the Edison Co.	Estimated by the Bureau of Municipal Research
Coal	$3,296	$6,151	$4,125
Labor	2,944	10,282	4,683
Supplies for operation	400	1,576	326
Repair material	550	.....	624
Ash removal	260	692	373
Gas lighting	65	65	65
Total	$7,515	$18,766	$10,196

TABLE B

	City Estimate	Edison Estimate	Bureau Estimate
Cost of current equivalent to that used during test	$21,015	$21,015	$21,015
Saving by shutting down engines	7,515	18,766	10,196
Effect on City of Edison Service	$13,500 (loss)	$ 2,249 (loss)	$10,819 (loss)

HOBLITT STEAMER SYSTEM

Description of a steam engine system for truck use, said to consist of a new steam generator, a new oil boiler and a new hydraulic transmission (invented by Enoch Rector).

The essential part of the generator is a long double cone-shaped plug, part of which projects into the combustion chamber under the generator, and part reaches through the crown sheet or bottom plate of the boiler, through the water and about 2 in. above the level of the water. Numbers of these plugs are inserted through the crown sheet, as many being used as practicable. Their function is a double one,—making complete combustion possible by presenting a heated surface for the burning gases and conducting the heat of combustion directly into the water. They are really modified "legs" on the crown sheet, but carried through to the other side. The inventor claims that in the ordinary boiler the crown sheet cools down that portion of the burning gases that comes directly in contact with it, so that the combustion is not perfect in the thin layer of gas next to the comparatively cool metal. The lower ends of the plugs, however, are designed to reach high temperatures and become quite hot in actual practice, and it is against this quite hot metal that the burning gases impinge and complete their combustion uncooled.

It is stated that tests conducted by Prof. Harry L. Parr, of Columbia University, showed in the exhaust gases ½ of 1 per cent of carbon monoxide and from 11.5 to 14 per cent carbon dioxide. (No complete results of the tests are published) (*Automobile Topics*, vol. 42, no. 3, page 239, May 271, *d*).

NEW WATER LEVEL INDICATORS, B. Grey

The question of water level indicators is attracting considerable attention in Germany, especially in connection with what corresponds to the Safety First movement in America. Several improved water level indicators patented recently are described in the present article.

Otto Voss has patented a device shown in Fig. 9, the essential characteristics of which are a movable water container with a counterweight located below the water level in the boiler, and further, a scale arranged in such a way that the part corresponding to the low water state in the boiler responds to smaller differences of level than that corresponding to the high water state.

The vessel *b* is suspended in the usual manner and has its lower end connected with the water space of the boiler and

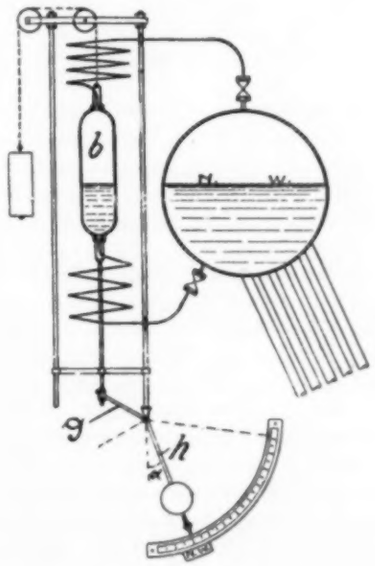

FIG. 9 VOSS WATER LEVEL INDICATOR FOR STEAM BOILERS

its upper end with the steam space. Hence as the water level varies in the boiler, there occurs a similar variation in the vessel *b*, which latter is provided with a rod pressing against the lever *g*. As the amount of water in the vessel *b* varies, the latter moves either up or down in accordance with the variation of relative weight of the vessel and the counterweight. As it moves it causes the motion of the arm *h* of the lever *g* with its counterweight at the other end and in this way the pointer moves over the scale. The section of the scale which corresponds to the lowest water level takes care of the smallest angle of deflection α of the lever; since the moment of torsion produced by the load on the lever varies as the sine of the angle of deflection, the deflection of the lever for the same amount of variation of level will be greater for the smaller angles than for the larger angles, which makes the apparatus more sensitive for indicating variations at low level than at high level, which is as it should be. The sensitiveness of the apparatus is still more increased through the fact that the changes in volume of the liquid in the vessel *b* are actually greater than the changes in level in the boiler because of the sinking of the vessel with the increase of the weight of water in it (*Neue Dampfkesselwasserstandszeiger*, B. Grey, *Sozial-Technik*, vol. 15, no. 5, p. 45, March 1, 1916, 3 pp., 3 figs. *d*).

Thermodynamics

EXPERIMENTS ON THE FLOW OF HEAT IN METAL SHEETS, Sidney Skinner

The paper describes a method for showing to a class of students the conductivity of heat along a metal bar. The usual method is to place the bar under a specially prepared paper which changes color with heat, but this is not satisfactory because paper is too poor a conductor and the color effect has no definite edge. The author, therefore, devised a different method, namely, placing over the bar a thin layer of tin. As the tin melts it forms a sharp edge which constitutes an equi-temperature line corresponding to its melting point of 227 deg. cent. Inside this sharp line other equi-temperature regions are shown by the oxidation colors of the tin, each oxidation color seemingly corresponding to a definite temperature. When the melted tin solidifies the crystals arrange themselves differently than in the original plate, and the equi-temperature line may be very sharply developed by washing the surface with a mixture of bleaching powder and hydrochloric acid.

The author made a series of tests to compare the flow of heat in a sheet of metal cut with a tongue protruding from one edge and the flow of electricity from the tongue into a plate. It is an electrical law that if a plate be cut along a line of flow, no change will take place in the equi-potential lines in the portions which are formed by the cut. The author made a similar experiment with the flow of heat in a tinned sheet by cutting a longitudinal opening along the tongue and through the sheet in the direction of flow. The flow of heat was studied separately in the two portions, and on putting them together the equi-temperature line was the same as in the uncut sheet.

Another problem examined was the flow of heat into a circular disc and out from a circular disc, around the corner of an L-shaped strip, and into the vanes of an air-cooled cylinder. The results were found to be closely analogous to the flow of electricity in similarly shaped conductors. In the discussion which followed, Dr. R. S. Willows said that a similar method had already been used by Voigt to compare the thermal conductivity of different metals. He used an organic substance which melted about 41 deg. cent., and gave a very sharp line on resolidification.

Experiments involving the use of indicating paints are described in "Light, Visible and Invisible," by Prof. S. P. Thompson (*The Physical Society of London, Proceedings*, vol. 28, part 3, p. 119, April 15, 1916, 5 pp., 3 figs. *e*).

FLOW OF HEAT FROM SOLIDS TO AIR, E. E. Snyder, C. S. Robinson and W. K. Lewis

The investigation was undertaken to determine whether the coefficient of heat transferred from solids to air is proportional to the square root of the gas velocity (J. W. Richards) or to the cube root of the velocity (Irwin Langmuir). A complete description of a method of testing is given.

The writer came to the conclusion that the value of the coefficient of heat transferred, K, up to the temperature employed is independent of the temperature and is a function of the velocity alone. He derived an equation

$$K = \frac{39.6V}{V + 3.67}$$

where K is the coefficient of heat transferred from solid to air in B.t.u. per square foot of heating surface per degree fahrenheit difference in temperature per hour, and V is the lb. of air per second flowing through each square foot of section, the section being taken at right angles to both heating surface and direction of flow of the air. The expression is apparently independent of temperature up to 750 deg. fahr. (*The Journal of Industrial and Engineering Chemistry*, vol. 8, no. 6, p. 515, June 1916, 2 pp., 2 figs. *et*).

Varia

SOME PROPERTIES OF THE WATER IN COAL, Horace C. Porter and O. C. Ralston

The paper deals with the manner in which water may be held in coal and how its properties and those of the coal are affected by the condition in which it is held. The author considers as problematical the condition in which the so-called "water of combination" exists in coal. In the true chemical sense the water is probably not "combined," that is, united with another substance in definite proportions as determined by its relative molecular weight and the number of molecules. The behavior of coal with respect to moisture resembles so strongly that of many substances known to be colloidal that there can be no doubt of the colloidal nature of part of the coal substance.

Different kinds of coal contain in the air-dried condition widely different percentages of water. Part of the water in coal is held more tenaciously than free water by forces due to colloidal conditions which in a practical way are manifested in the following features: (1) The impossibility of drying coal completely in an atmosphere not absolutely dry; (2) the extremely hygroscopic character of dry coal; (3) large changes in the moisture content and therefore in the weight of some kinds of coal by changes in the humidity of the atmosphere; (4) more rapid drying out of moisture from the mature Appalachian coals than from the younger, more hygroscopic coals of the Middle West and West. These factors depend on the fact that part of the water in coal has a vapor pressure below normal.

The development of heat by wetting coal is dependent on the same explanation as that of the lowering of vapor pressure; namely, the densified condition of the water in the colloidal state, and consequently will vary in different coals. The fact that the size of the coal or its fineness of division makes little difference in the heat of wetting is probably to be explained by assuming that each particle of the dried coal acts as a sponge. Water is drawn into the pores of the larger pieces with nearly the same facility as it is into those of very small particles. Heat may be produced by two processes, the mere penetration of the liquid into minute capillaries and the formation of a colloidal condition possibly more readily entered into by water than by other liquids.

The free extraneous water adhering to broken coal may vary between very wide limits as affected by the fineness of division and the kind of coal. (Department of the Interior, Bureau of Mines, *Technical Paper 113*, Washington, 1916, 28 pp., 3 figs., *et.*)

An investigation made in a number of British boiler plants in four different industries, cotton mills, woolen mills, paper mills, and dyeing, bleaching and calico-printing works, has shown that sixteen paper mills are giving remarkably good results—an average of 76.65 per cent efficiency. Fourteen cotton mills are slightly better than the average, with 65.11 per cent efficiency, while the woolen mills and the dyeing industries were found below the average in efficiency.

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